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THE FIXED STARS.

W. H. S. MONCK.

III.

One of the most fundamental problems in connection with the fixed stars is that of their distances from the Earth; but the solution is beset with a number of difficulties many of which are, I believe, known only to those who have dealt with the subject practically. Others, however, can be made intelligible to all. The general principle is the same as that adopted in the case of distant or inaccessible objects on the Earth. We measure a base line and observe the angles made by the lines joining each end of this base line to the object, from which the length of the sides of the triangle thus found can be computed by the ordinary formulæ of trigonometry. If the base line is very short compared with the sides, the latter are nearly equal to each other. The formulæ used rest on the assumption that the three angles of a triangle are always equal to two right angles (or to 180°). If, as some metaphysical mathematicians maintain, this principle may fail us in the region of the fixed stars, our efforts to ascertain the distance of any of them would prove fruitless; but I know of no reason, astronomical or philosophical, for doubting its truth. But this principle at once shows us one difficulty in the problem. We cannot measure angles with absolute accuracy. Suppose that the real value of the vertical angle of our triangle was half a second, if we made an error of half a second in measuring the base angles, the vertical angle might altogether disappear with the result that the distance of the star would appear to be infinite; or, on the other hand, we might make the vertical angle double what it really is, which with angles as small as this would reduce the distance by one-half. Again the star is displaced by refraction and if our base line was a pretty long one the amount of refraction might be considerably different at the two ends. Moreover, as the earth is moving and the star may be moving also, an error might arise if the two angles were not measured at the same instant. Finally a base line measured on the earth would be really an arc of a great circle instead of a right line, and computation

would have to be resorted to in order to find the real measurements of the base line and base angles of the plane triangle with which we were dealing. It has been found impossible, however, to measure any base line on the earth which will give a sensible angle at the star. The two base angles as measured may not be exactly equal to two right angles, but they are as likely to be greater as to be less, and the angle found manifestly depends only on errors of observation and calculation.

We must therefore find a longer base-line to start with, and such a line is afforded by the diameter of the earth's orbit. Its length indeed is not exactly known, though the error of the most recent determinations cannot be very large. But even if it were not known, we could at all events find the proportion between the distance of the star and that of the Sun. The distance of the Sun is indeed our real unit of measurement as regards the distances of the fixed stars, and it is from it that any other units of measurement that we may adopt must be derived. At the end of six months (or rather a little more or less than six months, depending on the eccentricity of the earth's orbit) the earth will be at the opposite end of the diameter of its orbit. We thus obtain a base line of over 180,000,000 miles in length and if we can ascertain the vertical angle we can measure the distance of the star. Half of this vertical angle is known as the parallax (or annual parallax) of the star; and therefore investigating the parallax of a star is the same thing as trying to measure its distance. But the difficulties which meet us in this inquiry are even more numerous than before. First the position of the star is affected by the aberration of light as well as by refraction. Then its position is ascertained by its right ascension and declination, the first of which depends on the exact position of what is known as the first point of Aries, and the second on that of the pole—neither of which points are precisely fixed—while any error in the sidereal time of the observation, from whatever cause arising, may also lead us astray. The angle to be computed is so minute that errors arising from these and other sources may completely conceal it. All that we can say in most cases is that it is extremely small. There is strong reason to believe that of no star hitherto attempted does the parallax amount to as much as one second. Let us see what this means. With angles as minute as this, the arc may be considered as equal to its chord, and there being 206,265 seconds in an arc equal to the radius of a circle, the distance of the star is at least 206,265 times that of the Sun. From this principle that the arc is equal to the chord another result follows. If we could

determine the parallaxes of two or more stars their distances would be inversely as their parallaxes. If we adopted as our unit of distance that of a star with a parallax of one second (in other words 206,265 times the distance of the Sun), the distance of any other star will be $\frac{1}{p}$, where p is the parallax expressed in fractions of a second. This would I think be a more convenient unit of distance than that usually adopted by astronomers; viz., a year's light-passage or the distance which light travels in a year. I find the expressions for the distances of stars on this latter scale cumbrous, besides involving in every case an unnecessary arithmetical computation.

The mode of measuring parallaxes which I have mentioned has been to a great extent superseded by another. If we take two near stars we may regard refraction and aberration as the same for both, and in considering their *relative* parallax we get rid of the necessity of these corrections. Now if one of these stars is so far away that the lines joining it to the end of the base line may be regarded as parallel, the vertical angle at the other star is equal to the difference between the angles which apparently separate the two stars when we are at opposite ends of the base line. We could thus obtain the parallax of one star if we were certain that the distance of the other star was enormously greater. But in any case we can get the *difference* between the parallaxes of the two stars, as will be easily seen, if we suppose a third star at a really infinite distance and the parallaxes of both stars measured in relation to it. This method has been frequently tried in recent times. A particular star is supposed, on account of its brightness, or for other reasons to be mentioned hereafter, to be nearer to us than its neighbors. We compare its position with one or more of these at intervals of six months (or some other calculable period) and determine the relative parallax. Of course, as the brightness of a star does not depend solely on its distance, the fainter star may be the nearer of the two. In this case if our measures were sufficiently accurate we should obtain a *negative* parallax for the brighter star. Or the small star may be a satellite of the larger one. In such cases it is certain that the difference in their distances would elude any means of observation that we now possess, and the relative parallax would be 0. A positive parallax indicates that the star is nearer than the companion or companions with which it is compared, and if the distance of the faint star is enormously great that of the brighter one may be deduced from the relative parallax almost as confidently as if it

were an absolute parallax. Suppose for instance that we obtain a parallax of 0″.40 on comparing with a star whose parallax we have reason to believe does not exceed 0″.02, we have as much accuracy as we can expect under present circumstances. The grounds for thinking that certain stars are very distant will be mentioned hereafter.

Recently a method has been introduced in which instead of measuring the distances between the stars in the sky we measure the distances between their images on a photographic plate. In this way we can use several comparison stars, and measures may be made by different persons and repeated as often as is thought desirable. Relative parallaxes only of course can be obtained in this manner, and if we obtain different results from different comparison stars we can take a mean. These different results however may arise from the fact that some of the comparison stars are nearer to us than others—in which case the largest parallax obtained from any comparison star is most likely to be the correct one.

Hitherto we have supposed the stars to be motionless; but in reality they are all moving—or at least moving relatively to the solar system—and unless we know their motions our researches on parallax may lead us altogether astray. The proper motions of a considerable number of stars are now pretty well known and can be allowed for, while a sufficient number of observations might enable us to make a simultaneous determination of the parallax and the proper motion. The proper motion of stars being very small may be usually regarded as taking place in a right line or arc of a great circle and with uniform velocity. But to this rule there are exceptions. Double stars revolve round their common centre of gravity in orbits that have only been accurately determined in a few instances—the pair having usually a rectilinear motion on the celestial sphere in addition to this motion of revolution. A puzzling case arises where no companion star is visible, yet the bright star moves as if its motions were controlled by a dark companion. Sirius was long in this condition. Procyon is so still, and many other stars whose motion is now supposed to be rectilinear may prove to be really influenced by invisible companions.

Having regard to these difficulties it is not surprising that we should possess very few reliable determinations of parallax. Indeed it has more than once happened that after two or three fairly coincident determinations giving a sensible parallax, another observer arrived at a totally discordant result. But I

think it may be affirmed that the parallax of the bright Southern star, α Centauri does not differ very much from 0″.75: that 61 Cygni, a star scarce visible to the naked eye, has a parallax of about 0″.45, Sirius probably about 0″.40 and Procyon about 0″.25. Some other examples might be given, and I think, while it may be asserted that no known star has a parallax of one second, it may be equally affirmed that several known stars have parallaxes exceeding one-tenth of a second. The distances of the nearest stars thus range from 200,000 times to 2,000,000 times that of the Sun. That the distances of many stars, though very great, does not even approach the infinite, we have other reasons for believing. One of these is afforded by the case of the double stars already alluded to. When we find two stars easily separable by our telescopes and yet revolving round each other in a limited time, it is plain that either their distance from us must be (comparatively speaking) moderate or else the mass of the system must be enormous. α Centauri is such a double star. The period of revolution is under a century and the pair can, I believe, be separated (I have never seen them) with a good field glass. Here we have a remarkable confirmation of the parallax otherwise determined. The case is not very dissimilar with Sirius. The glare of the great star indeed usually conceals the faint one but otherwise in most situations the separation would not be very difficult, while the period of revolution is shorter than that of α Centauri. 61 Cygni is also an easily separable double star but its period is probably long. It gives, however, another evidence of nearness which the other three stars mentioned also exhibit though in a minor degree, *viz.*, large proper motion. It changes its position among the neighboring stars by about five seconds every year. If its parallax was only one-tenth of a second this would mean that it travels at least 50 times the distance of the Sun from the Earth every year—a velocity of not less than 150 miles per second. Such a result would be rather startling especially if we had to assign immense masses to the bodies which are flying through space at this rate. And we have other reasons for concluding that such enormous velocities are altogether exceptional. For by means of the spectroscope we can measure with greater or less accuracy the velocity with which a star is approaching or receding from us in miles per second, and we do not find in this way, at least so far as observations hitherto made on ordinary stars extend, any such velocities as these. The average rate of motion in the line of sight of some fifty stars examined by Vogel is only about ten miles a second and none of the fifty

exceed three times this figure. A star with a motion of one second per annum on the celestial sphere will therefore probably have a parallax of not less than one-tenth of a second. We know of over eighty such stars, and I think we may conclude that there are at least that number of stars whose distance does not exceed 2,000,000 times that of the Sun, or 10, if we adopt the unit of distance which has been suggested. Not of course that proper motion is a decisive test of the nearness of a star. A near star may have small proper motion because it is moving directly towards us or away from us, or if the Sun is also moving because its motion is nearly equal and parallel to that of the Sun. So the motion of a comparatively distant star may be exaggerated because it is moving nearly at right angles to the line of sight and is situated in a part of the sky where the Sun's motion is most influential in producing apparent motions in the stars; while, finally, different stars no doubt differ in velocity as well as in mass and brilliancy. No one symptom of nearness can be relied on as conclusive, but when several of them combine we may feel pretty confident of comparative nearness without actual measurement. Take for instance the double star γ Virginis whose parallax has not, so far as I am aware, been hitherto measured. It consists of two stars easily separable, with a moderate period of revolution. It is fairly bright and, judging from the quality of the light, its brightness does not appear to be due to an unusually high temperature. Its proper motion though not very large is also considerable. I think I may venture to predict that its parallax will be found to exceed one-tenth of a second.

Now take another case—the star 6 Cygni for which Sir Robert Ball found a parallax of nearly half a second while Professor Asaph Hall found a negative parallax. Comparing it with 61 Cygni, it is also a double star somewhat fainter but not very much. But the quality of its light indicates that it is at a much higher temperature. The pair is very easily separable but though observed for years no motion of revolution can be positively asserted. The system is probably binary but the period seems to be very long. Its proper motion is far less than that of 61 Cygni yet by no means insignificant. On the the whole I have little doubt that Sir R. Ball's parallax is largely in excess of the true one, while Professor Hall's probably errs on the other side. I would not venture to predict the ultimate result, but perhaps one-tenth of a second may not again be very far from the truth and perhaps rather in excess than defect. Thus on the one hand the distances of all the stars are such as to elude accurate measure-

ment with our present appliances, but on the other hand there are many cases in which they do not surpass our powers of estimation. And faint telescopic stars may have considerable parallaxes —their faintness being due to their small masses and low temperatures.

Sirius, according to the estimate which I have adopted, is about 500,000 times as remote as the Sun. At that distance the Sun's light would be reduced in the proportion of 250,000,000,000 to 1. The number of stars visible in the great Lick telescope is estimated at 100,000,000 millions, of which about one-half would be above the horizon at one time. What would the illumination of our midnight sky be if every one of these hundred millions of stars was as bright as Sirius? Yet Sirius, if brought as near to us as the Sun, would (according to my estimate) give 5,000 times as much light as this.

I might fill—and waste—pages in illustrating the vast distances of the stars compared with those of terrestrial objects. We are in fact dealing with magnitudes of a different order and require to commence with a different unit of distance. Taking such an unit the range of distances with which we have to deal is not so very great. On the scale which I have suggested the distance of the nearest known star, α Centauri, is about 1.3, and there is probably not a single star visible in the Lick telescope whose distance exceeds one million. Doubtless there are stars much more remote than this, but they are beyond the range of our present telescopes. The distance of Sirius is about 2.5. Remove it to the distance 25,000 and it would become fainter by twenty magnitudes which would render it invisible in any known telescope. And in this estimate I have assumed that no light is lost in transmission. If light is lost—and it is pretty certain that *some* light is—the decline in brightness with distance would be even more rapid than this. A million is therefore probably rather a liberal estimate for the maximum distance of the stars with which we have to deal in Astronomy.

CONSTELLATION STUDY.

WINSLOW UPTON.

VII.

We will consider in this article the constellations which are in the third division of the sky—that lying between 12 and 18 hours

right ascension. The circumpolar groups, Ursa Minor and Draco of this division, were described in the IVth paper of this series. The zodiacal constellations of the division are Virgo, Libra and Scorpio.

Virgo. This name is given to a very large area lying southeast of Leo. It contains a number of bright stars which can be readily recognized, though they do not form any special geometrical figure. The southernmost conspicuous star, α Virginis, also named Spica, is of the first magnitude and is recognized without difficulty because it is quite solitary. Or, it makes with Arcturus and Denebola a triangle whose sides are roughly 30° in length, Spica the southernmost. (In May, 1894, the planet Saturn is about 5° north of Spica.) Starting from Spica there are six third magnitude stars to be found. 11° north of Spica is ζ, 13° east of ζ is γ, and 6° still further east is η. 8° further east and 2° further north of η is β. Returning to γ (which is a beautiful double star in a telescope), and looking northeasterly, we find δ and ε not quite in line, 6° and 8° respectively separated from each other. North of β are three fourth magnitude stars which mark the position of the virgin's head, her body extending in a southeasterly direction through the area. There is also a fourth magnitude star, θ, between α and γ, which will attract attention in tracing the stars. The lines on the chart show a different way of identifying the stars, including those fainter than the ones just mentioned. The star η is not far from the autumnal equinox, and this part of the equinoctial colure may be roughly drawn by passing a line from it to the pole star. It will go through δ Ursæ Majoris, the fourth star in the Great Dipper.

Libra. The characteristic figure of this group, which lies southeast of Virgo is two second magnitude stars lying in a northeast-southwest line about 10° apart. Parallel to this line and about 5° further southeast are two fainter stars somewhat nearer together, which seem to imitate faintly the two first mentioned. This constellation is the only one in the zodiac which does not bear the name of a living creature or living creatures. In Ptolemy's catalogue it is called *Claws*, and was therefore apparently taken out from the next group Scorpio, to complete the number 12 for the zodiacal constellations.

Scorpio. This is one of the few constellations which bear a rough resemblance to the object suggesting the name. It is a splendid group, easily traced. Southeast of Libra is the bright red star α Scorpii or Antares which is the central one of the three about 3° apart. These three stars point northwestward to δ

which is the central one of the three conspicuous stars β, δ, π, in a curved line convex towards the northwest. Though the claws of the primitive scorpion may have been long enough to extend to α and β Libræ, the reduced claws of the classical figure are of no mean size and are marked each by a star near the extremity. The southern claw stretches westward from δ to γ, a third magnitude star about 15° west of δ, and the northern claw stretches northward from β to ξ, a fourth magnitude star 8° north of β. Another way to trace this part of the figure is shown on the chart. The figure should be completed by following towards the south and east the long tail of the scorpion curving northward to the two stars near together, λ, υ. In the northern part of the United States the southernmost of this line of stars are seen with difficulty.

In naming the constellations it is customary to use the form Scorpio as the nominative, but the form Scorpii instead of Scorpionis for the genitive, the latter formed from a poetic equivalent Scorpius.

North of these zodiacal constellations are seven groups which we will take up beginning with the northwestern one.

Coma Berenices. This group is readily recognized as a cluster of twenty-five or thirty faint stars northeast of the triangle marking the eastern part of Leo.

Canes Venatici. This name was given by Hevelius to the rather vacant space south of the handle of the Dipper. Two hunting dogs were depicted with a leash held in the hand of Boötes. There is only one bright star in the area, which is about half way between the handle of the Dipper and Coma Berenices and is in the collar of the southern of the two dogs.

Boötes. The conspicuous star of this group is the brilliant gem noted in primitive and classical writings as Arcturus. It can readily be found by following the curved line made by the handle of the Great Dipper outward from the bowl. A coffin shaped quadrilateral made by this star, α, with η, ε and ρ is the characteristic figure of the area, and is in the body of the herdsman. Northeast of the line ε, ρ, are three third magnitude stars which mark the head and shoulders, β, δ and γ. A different plan for tracing this group is given on the chart.

Corona Borealis. This pretty group lies just east of the central part of Boötes, and consists of a curved line of seven stars which may be readily imagined to constitute a garland or wreath.

Hercules. This large area is occupied by a giant form whose head is at the south, and whose legs extend the one over Corona

Borealis and the other to Draco at the stars γ, β, of that group. The characteristic figure is a quadrilateral of third magnitude stars η, ζ, ε, π which are about 15° or 20° northeast of Corona Borealis. 2° east of π is ρ, which may be thought of as a short handle to the rather deep dipper made by the quadrilateral. In the side $\eta\,\zeta$ about one-third the way from η, and about at the point at which the line $\rho\,\pi$ if prolonged would meet it is the great star cluster in Hercules. This quadrilateral is in the giant's body. Other stars in the group can be found from it thus; From η, the northwest star of the quadrilateral, the star τ lies northwest about 10°. Several fainter stars west of it are in the leg of the hero. The line $\pi\,\rho$ if prolonged eastward leads to θ, a fourth magnitude star from which ι, a star somewhat brighter, lies about 10° north and marks the other leg. The diagonal line $\eta\,\varepsilon$ leads to δ in one shoulder, and μ which lies about 8° northeast from δ marks one arm. The other shoulder is marked by two stars β and γ about 3° apart, the former in the prolongation of the line $\mu\,\delta$. The head is marked by a third magnitude star which makes an equilateral triangle with the two stars of the shoulders, δ and β. It must not be confounded with the brighter star about 5° east of it which is α Ophiuchi. A little group of fourth magnitude and fainter stars occupies the southeastern part of the area, about 20° south of the bright star in Lyra known as Vega.

Ophiuchus and *Serpens*. These constellations cross each other, the latter consisting chiefly of a line of stars representing the serpent which the serpent carrier holds in his hands. The head of Ophiuchus is at the star α which is about 5° east of α Herculis. As in the case of the two other gigantic figures just described, Boötes and Hercules, a triangle of stars marks the head and shoulders. The triangle in Ophiuchus is lettered α, β, $\varkappa$. The eastern shoulder β has a fainter adjacent star γ, and similarly the western shoulder $\varkappa$ has a companion ι. The serpent's head is marked by a number of faint stars about 10° west of the two stars, β, γ, in Hercules' shoulder. Following the line southward, β, δ, α, ε, μ, all in Serpens as on the chart, we reach the place where the serpent is hidden by the western leg of Orphiuchus. Continuing the line of stars, we have δ, ε Ophiuchi marking one hand, ζ one leg and λ the other leg. The line of bright stars just named, beginning with δ Serpentis and omitting μ Serpentis, is quite straight and conspicuous. A fourth magnitude star 10° south of η marks the direction of the eastern leg of Ophiuchus. The serpent appears again near η Ophiuchus and can be traced, but not as plainly as before, by the stars lettered ξ, ζ, η and θ Serpentis. Between ξ

and ζ is a fourth magnitude star lettered ν Orphiuchi marking the other hand. These constellations illustrate the difficulties under which the revisers of the ancient system of constellations labored in adapting them to modern needs. It would have been simpler to have given one name to the whole area, retaining the figures of the serpent and his holder, and revised the letters so that the same letter would be used but once. Argelander's division, adopted in these articles, does not agree exactly with those on Poole's chart.

South of the zodiacal group in this division are three constellations wholly or in part visible in the United States.

Corvus. This is a small but conspicuous constellation southwest of Spica, and readily found. It consists of four stars forming a quadrilateral whose sides are of unequal length. South of the southwestern star is a fifth star, 2° distant from it, much fainter than the others though lettered α.

Centaurus. The greater part of this constellation is below the horizon of northern observers for whom these articles are prepared. The head and shoulders however can be seen, the former consisting of three fourth magnitude stars near together, and the latter marked each by a star, the one of the second and the other of the third magnitude, the two about 11° apart. These stars are quite plainly seen when the constellation is on the meridian. They are about 20° southeast of Corvus. Two other third magnitude stars, lettered η and ζ as given on the chart, may also be seen as far north as latitude $40° - 45°$ under specially favorable circumstances.

Lupus. This constellation also is mostly concealed from northern observers. Its characteristic figure is a triangle of third magnitude stars in south declination $40° - 47°$. Faint stars seen south of the body of the Scorpion belong to the northern part of this area in which the head of the Wolf is drawn.

The zodiacal constellations of this division are those through which the Sun passes in the autumn, and are therefore south of the celestial equator. The ecliptic passes near Spica, α Libræ and β Scorpii, and through the southern extension of Ophiucus, which at this place comes between the zodiacal constellations Scorpio and Sagittarius. The celestial equator passes very near η, γ and ζ Virginis.

The constellations of this division are favorably situated for study in the evenings of spring and summer.

The following table gives the magnitudes and approximate positions of the stars in each group.

Approximate Positions of the Leading Stars in the Constellations Between XII^h and XVIII^h Right Ascension, Omitting Circumpolar Constellations.

Coma Berenices.

No bright Stars.

Canes Venatici.

Name.	Magnitude.	Right Ascension. h.	m.	Declination. °	′
12	3.1	12	51	+ 38	51

Boötes.

η	2.9	13	50	+ 18	54
α	0.0	14	11	+ 19	42
ρ	3.6	14	27	30	48
γ	3.1	14	28	38	44
ε	2.6	14	41	27	30
β	3.6	14	58	40	47
δ	3.5	15	12	+ 33	41

Corona Borealis.

β	3.8	15	24	+ 29	27
α	2.4	15	30	27	3
γ	4.2	15	39	26	37
δ	4.6	15	45	26	22
ε	4.1	15	53	+ 27	10

Hercules.

τ	3.9	16	17	+ 46	33
γ	3.8	16	17	19	23
β	2.8	16	26	21	42
ζ	3.1	16	38	31	46
η	3.7	16	40	39	6
ε	4.0	16	56	31	4
α	3.2	17	10	14	31
δ	3.3	17	11	24	58
π	3.4	17	11	36	56
ρ	4.0	17	20	37	15
υ	3.9	17	37	46	3
μ	3.5	17	43	+ 27	47

Ophiuchus.

δ	2.8	16	9	− 3	26
ε	3.4	16	13	− 4	27
ζ	2.8	16	32	− 10	22
$\varkappa$	3.4	16	53	+ 9	32
η	2.6	17	5	− 15	36
θ	3.4	17	16	− 24	54
α	2.2	17	30	+ 12	38
β	2.9	17	38	+ 4	36
υ	3.5	17	54	− 9	45

Serpens.

δ	3.9	15	30	+ 10	53
α	2.7	15	39	+ 6	44
β	3.8	15	42	+ 15	44
μ	3.5	15	44	− 3	8
ε	3.7	15	46	+ 4	46
η	3.4	18	16	− 2	56

Name.	Magnitude.	Right Ascension. h	m	Declination. °	′
		VIRGO.			
β	3.7	11	45	+ 2	19
η	4.0	12	15	− 0	7
γ	2.8	12	37	− 0	54
δ	3.7	12	51	+ 3	56
ε	3.0	12	57	+ 11	29
α	1.2	13	20	− 10	38
ζ	3.5	13	30	− 0	5
		LIBRA.			
α	3.0	14	45	− 15	38
β	2.7	15	12	− 9	1
		SCORPIO.			
γ	3.2	14	58	− 24	53
π	3.1	15	53	− 25	50
δ	2.5	15	54	− 22	21
ξ	4.0	15	59	− 11	6
β	2.9	16	0	− 19	33
σ	3.0	16	15	− 25	21
α	1.1	16	23	− 26	13
τ	2.9	16	30	− 28	1
ε	2.2	16	44	− 34	5
υ	2.8	17	24	− 37	13
λ	1.7	17	27	− 37	2
θ	2.1	17	30	− 42	56
κ	2.6	17	36	− 38	58
		CORVUS.			
α	4.3	12	3	− 24	11
ε	3.1	12	5	− 22	3
γ	2.8	12	11	− 17	0
δ	3.1	12	25	− 15	58
β	2.8	12	29	− 22	51
		CENTAURUS.			
ι	3.0	13	15	− 36	11
ζ	2.7	13	49	− 46	48
θ	1.7	14	1	− 35	53
η	2.5	14	29	− 41	44
		LUPUS.			
α	2.6	14	35	− 46	57
β	2.8	14	52	− 42	44
γ	3.2	15	28	− 40	50

VARIABLE STARS.

J. A. PARKHURST.

VII.

A number of amateurs have been preparing to coöperate in the work of observing variable stars. Some have already begun and others are nearly ready. It is my intention to use this space for

the publication of specimen observations, the discussion of points which they suggest, hints in regard to methods, and whatever will aid the observer in this interesting work. To this end, correspondence is invited from all who are engaged in such observations or who wish to undertake them, and frequent reports are requested in regard to progress in the work or any difficulties which may arise. It is hoped that no one will refrain from reporting for fear that his work is not perfect, for perfection in this line has not yet been attained.

Mr. W. Dearden of Trinidad, Colo., has lately received a 9½-inch reflector with driving clock and circles, from the works of J. A. Brashear at Allegheney, Pa. He has been perfecting the adjustments of the instrument and has begun using it on variable stars. His observations of the recent maximum of 2815 U Geminorum will be mentioned later. Mr. Dearden writes: "It seems to me that it takes a pretty good eye and lots of practice to appreciate eleven steps between *f* and *h* in the U Geminorum group." This point is worth a suggestion. The magnitudes of *f* and *h* according to Baxendall are 11.2 and 12.3. As stated in the December POPULAR ASTRONOMY, page 163, the value of a step for experienced observers is generally about one tenth of a magnitude, but it would not be well to attempt to regulate your step value by any such arbitrary quantity. Let your own eye determine what your personal step value shall be—don't attempt to see through another man's eyes. Quite likely your step value will be two or three tenths of a magnitude to begin with, and gradually and unconsciously grow smaller by practice.

Mr. J. D. Devor of Elkhart, Ind., has had a low power eye-piece fitted to his 3-inch refractor and expects to begin work before April 1. He writes: "I have enlarged about a dozen of your little star charts in the POPULAR ASTRONOMY, the first larger charts I enlarged four times, and the smaller nine times." A word about enlargements and the scale of charts. All the charts so far given, except those in the December number and the enlargement for 2815 U Geminorum in this number, are on the same scale, ¾-inch to 1° declination. This is the scale of Argelander's Durchmusterung charts and will generally be sufficient for use with a magnifying power of 20 to 40. Where the stars are crowded or the variable becomes faint it is often an advantage to use a higher power after the field has become familiar. In such a case the scale of the enlargement should be adapted to the power used. If a power of 25 is used with the original charts, a two-fold enlargement will be best for 50, a four fold for 100, etc.

Mr. David Flanery of Memphis, Tenn., asks for an illustration of the method of predicting a maximum from the "elements" such as the following (see February number, p. 264):

107 T Cassiopeiæ. 1871 March 31 + 445.0 E.

I failed to state on the page above cited that the length of period is given in days. In practice astronomers compute such maxima by the aid of the "Julian Period" which is a consecutive numbering of the days, beginning 6607 years ago. The following table gives the Julian number of the first day of each month for the years 1891-97:

JULIAN DAYS.

		1891	1892	1893	1894	1895	1896	1897
Jan. 1	241	1734	2099	2465	2830	3195	3560	3926
Feb. 1		1765	2130	2496	2861	3226	3591	3957
Mar. 1		1793	2159	2524	2889	3254	3620	3985
April 1		1824	2190	2555	2920	3285	3651	4016
May 1		1854	2220	2585	2950	3315	3681	4046
June 1		1885	2251	2616	2981	3346	3712	4077
July 1		1915	2281	2646	3011	3376	3742	4107
Aug. 1		1946	2312	2677	3042	3407	3773	4138
Sept. 1		1977	2343	2708	3073	3438	3804	4169
Oct. 1		2007	2373	2738	3103	3468	3834	4199
Nov. 1		2038	2404	2769	3134	3499	3865	4230
Dec. 1	241	2068	2434	2799	3164	3529	3895	4260

The first three figures are omitted after the first column but in use must be prefixed to each. By the aid of this table we can calculate the maximum of T Cassiopeiæ as follows—Chandler's Second Catalogue gives the Julian date of 1871, March 31,

240 4515.

To find the maximum occurring in 1894, take for instance from the table the Julian date of 1894, March 31 = 241 2919.

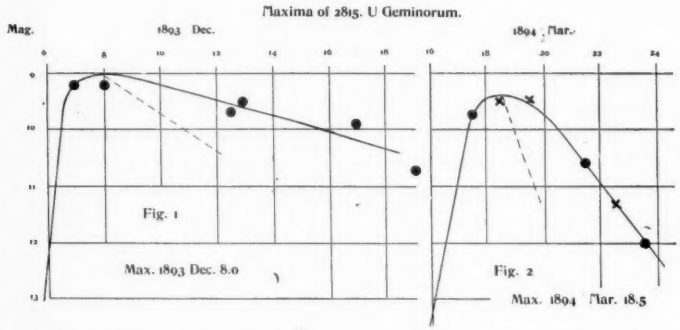
The interval between the two dates is 8404 days, which divided by the length of period, 445 days, gives 18 periods and 394 days or nearly 19 periods. To find when the 19 periods will be completed add to the date of the epoch the number of days in 19 periods—

Epoch = 240 4515
19 × 445 = 8455

241 2970 = 1894, May 21.

The date of maximum published in the April number, p. 378, is 1894, May 24. Whether the difference arises from a misprint or

the use of a different set of elements I do not know, as the editor does not give his authority for that table.



I give this month an enlarged chart for 2815 U Geminorum, the scale, (1½ inches = 1° Decl.), being large enough to show the group of 11 to 13 magnitude stars near the variable. These comparison stars are lettered according to the notation of Baxendall, who assigns the following magnitudes: $a = 8.6$, $b = 9.3$, $c = 9.2$, $d = 10.3$, $e = 10.6$, $f = 11.2$, $g = 12.3$, $h = 12.3$, $k = 13.3$, $l = 13.7$. As was predicted in the March number, p. 318, this remarkable variable passed a maximum in March, and furnished a good illustration of the advantage of coöperation in this work. After looking for it every clear evening since Feb. 27, I found it bright ($9^m.7$) March 17, $7^h\ 45^m$. It had been invisible March 15, and March 16 was cloudy. The question was—had it begun its rise the 16th? Fortunately Mr. Dearden at Trinidad, Colo., had been observing the locality with his new 9½ inch reflector, and on March 16th had not seen the variable although *l* was seen. So the rise from below 13^m to $9^m.7$ occupied less than 24 hours, at the rate of at least $\frac{1}{6}^m$ per hour. I asked Mr. Dearden for a copy of his observations, and though he had not begun using Argelander's method he kindly furnished the desired report. It is as follows:

1894 March 16 U not seen.
18 Not quite as bright as *b* or *c*, estimated about 10 mag.
19 Could not note change.
20 Snowing.
21 Snowing.
22 A trifle brighter than *h*, estimated 12 mag.
23 A little above *k*, equal to *x*.

These observations are especially valuable for locating (in connection with mine) the time of the sudden rise, so although Mr.

Dearden did not see the variable on the 16th, his observation of that date is very important.

My own observations are as follows:

1894 March	17	7^h	45^m	$c\ 2 - 3\ v,\ v\ 2 - 3\ d$
	21	7	40	$d\ 2 - 3\ v,\ v\ 4\ f$
	23	8	0	$f\ 4\ v,\ v\ 1\ h$
	26	8	20	$k\ 3\ v,\ v\ 1\ l$

Combining the two sets of observations gives the following magnitudes of the variable, expressed in terms of Baxendall's scale:

	Date	Mag.
1894 March	16.5	< 13
	17.5	9.7
	18.5	9.5
	19.5	9.5
	21.5	10.5
	22.5	11.3
	23.5	12.0
	26.5	13.6

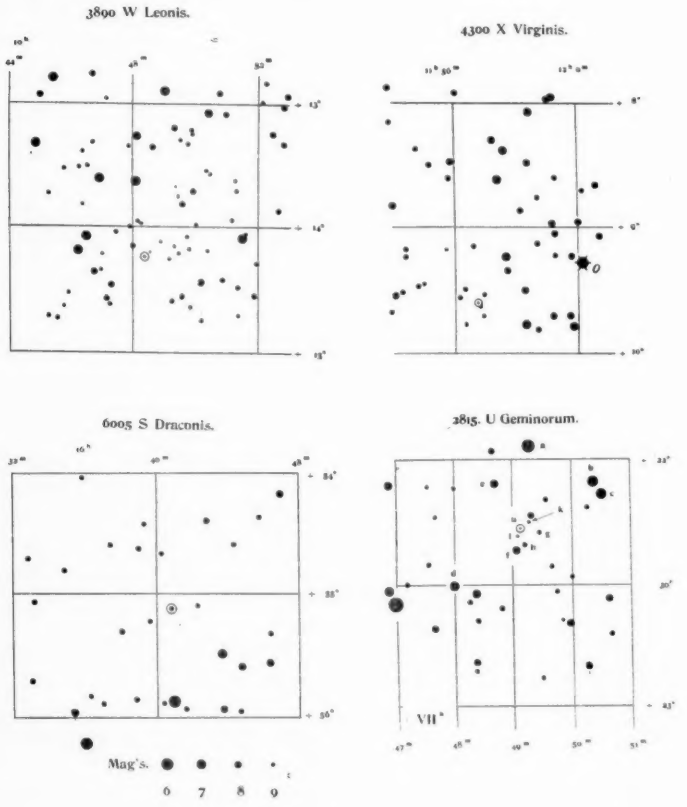
The light curve is given in Fig. 2, Mr. Dearden's observations being indicated by crosses, mine by dots. It will be interesting to compare this curve with that described by the same star at the preceding maximum in December, 1893. Fig. 1. The decline in March is three times as rapid as that in December. In the figures the magnitudes are given in the vertical column at the left, the dates in the horizontal line at the top.

A maximum of this star is predicted for 1894, May 17, in the April number, p. 378, but as its period varies from two to five months, little dependence can be placed on such a prediction. I should be glad to have copies of any other observation of this past maximum.

Charts are also given for 3890 W Leonis, 4300 X Virginis and 6005 S Draconis, all of which will be in position for evening observations this spring and summer, and of which observations are needed. 3890 and 4300 were discovered by the late Professor Peters at Litchfield Observatory of Hamilton College, and the charts are taken from his splendid series of charts. The variability of 3890 was confirmed by Henry M. Parkhurst, who found the elements:

1872 Feb. 12 + 394 d. 3 E.

According to these elements the maximum in 1893 was due Sept. 15, but a maximum was observed by Paul S. Yendell 1893, April 12. The elements above given would make the star become visible next September Mr. Yendell's maximum would indicate that it might become visible this spring. 4 or 5 inches aperture will be needed to deal with it.



The other Peters' star, 4300, has not been carefully observed and its period is uncertain. It is 3 mm. preceeding, 20′ north of the 4th magnitude star *o* (omicron) Virginis. March 23 it was 10.5 magnitude so that 3 inches will now show it well. There is an 11.5 magnitude star 2 seconds following, 0′.4 north of the variable.

6005 was discovered by Espin in 1892 and its variability confirmed by Yendell, who observed a minimum 1893, July 7, and a maximum 1893, Nov. 16. Its period is not known. Two inches aperture will suffice to observe it.

I take the following from Chandler's Second Catalogue:

No.	Star.	Place for 1900.		Redness	Magnitude.		Period days
		R. A.	Dec.		Max.	Min.	
		h m s	° ′				
3890	W Leonis	10 48 21	+ 14 14.9	3.5	9	< 14	394.3
4300	X Virginis	11 56 44	+ 9 37.7		8 — 10	12	?
6005	S Draconis	16 40 46	+ 55 7.2		7.3	9.2	?

Mrs. Fleming's new variable in Ophiuchus, B. D. + 1°, 3417, (see page 363) is brightening, and is now 7^{m}.5.

MARENGO, Ill., 1894, April 3.

A LESSON IN PARALLAX.

ORRIN E. HARMON.

A short time ago I was in conversation with a surveyor concerning solar eclipses. In the course of our talk, I remarked to him that in order to deduce the Moon's path over the Sun's disc, it is necessary to compute the Moon's parallax for times near the beginning and ending of the eclipse. He at once asked me what I meant by "parallax."

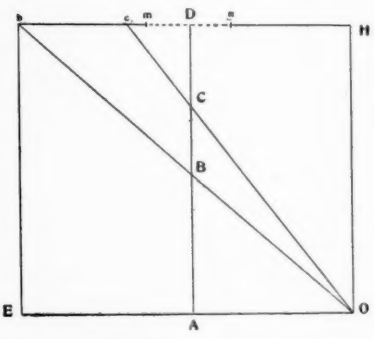
If this question comes from one whose occupation is essentially mathematical in its nature, how much more likely is it to be asked by those whose business is less closely related to the math ematics.

Indeed, I think it is not asserting too much to say that there are many intelligent people, and among them surveyors and teachers, who have not a clear idea of the meaning of parallax. Called by some other name, they might know what it is. In fact, there is scarcely a term used in astronomical science whose meaning is more clearly illustrated by every day experience than this one. The surveyor uses it whenever he computes the distance of an inaccessible object, and we all see it illustrated in our walks along the street or through the field. To explain the principle of parallax, I will present a diagram in which the idea can be carried out in the school room, at home, on the playground, and in many other places:

This figure represents a room, with a window whose sides are *m n*. On the side opposite the window, at A, stands a boy, and between him and the window stand two other boys, B and C who are in a line with A and the center of the window D.

Now A sees B and C in a line at right angles to the side of the room where he stands.

Suppose a fourth boy placed at O, the corner of the room, and on the same side with A. How do B and C appear to O? They are not in a line with him as they are with the boy at A. Nor does either of them appear in a line at right angles to the side E O. C has shifted his position so that he appears beyond the window at *c*; and B appears in line with the opposite corner at *b*. Their directions have changed.



How much is this change of direction? C has changed from a right angle by the angle COH; and B by the angle BOH. Which has changed the most? You at once answer, the nearer one B.

Now, this change of direction, caused by shifting the view from A to O, is the parallax of B and C, with respect to the line AO. B's parallax is the angle BOH, or its equal ABO; and C's parallax is the angle COH, or its equal ACO.

Notice also that B, the nearer one has the larger parallax. The greater the distance the smaller the parallax; and this is true whether the distances of B and C be taken from either A or O.

It follows that if we know the length of AO and the change of direction of B or C, as seen from the extremities of the line, the triangle having the vertex B or C can be constructed. Put in an algebraic expression, if $p =$ the parallax, a the length of AO, and d the distance BO, or CO, then $d \sin p = a$,

$$\text{or } d = \frac{a}{\sin p},$$

where the abbreviation "sin" denotes the sine of the parallax.

So the problem of determining the distance of a heavenly body an easy one, when once the parallax is known.

In locating the position of the heavenly bodies, the Earth's center is taken as a standard point. It would seem, then, that the direction of a heavenly body should change, when our point of view is changed from the Earth's center to the surface of the Earth. If we take a station on the Earth's surface where the Moon's center is in the horizon, that is when she is either rising or setting, and imagine a line to join our station with the Moon's

center, this line will be perpendicular to a plumb line, or the Earth's radius. This, of course, supposes the Earth to be a perfect sphere. In this case the Earth's radius becomes the base line, AO with the boy at A, to use our diagram. If we could change our position to the Earth's center, we would see the Moon (if she could be seen) with the boy at O, and her direction would be changed by an angle varying from 53′ to 61′, depending on the Moon's distance from the Earth. The same thing would happen with the Sun or planets, only the change of direction would be very much smaller on account of their greater distances.

When a heavenly body is on the horizon, its parallax is then called its horizontal parallax, and is the greatest parallax it can have. At any altitude, except in the zenith, there is always some parallax with the Sun, Moon and planets. In the zenith, the parallax is zero with respect to an observer, because he stands in a straight line joining the heavenly body with the Earth's center.

So immensely distant are the fixed stars, that they defy any measurement of parallax from any points on the Earth's surface. The diameter of the Earth's orbit affords a base line, from whose extremities, at intervals of six months, the astronomer can attempt the measurement of stellar parallax. But even a base line of 185,000,000 miles, appears so small seen from the nearest fixed star, that it is only by the most refined methods astronomers have succeeded in measuring the parallax of the nearest fixed stars.

In practical astronomical work, the Moon's parallax is an important element. In any calculation involving the Moon's position in the heavens with respect to an observer on the Earth, her parallax is an annoying visitor, and, like Banquo's ghost, will not down. For the purpose of showing the difference between the parallaxes of the Sun and Moon, I will cite a few facts related to recent solar eclipses.

In the recent eclipse of October 9, 1893, the magnitude of the eclipse at Seattle, Washington, was .29, with a duration of $2^h\ 4^m$. At Spokane in the eastern part of the state the magnitude was .22 with a duration of $1^h\ 51^m$. Seattle and Spokane are about 225 miles apart; and we see that in this change of 225 miles eastward from Seattle, the eclipse lost .07 of its magnitude. Taking Seattle as our starting point, the eclipse must lose .29 of its magnitude in order to fail entirely. At the rate of loss as above stated, we would have to go about 900 miles eastward from Seattle, for the magnitude to become zero. This brings us to the western part of North Dakota. In fact, the eastern limit

of the eclipse in the United States was defined by a line running from the northwest corner of North Dakota to Savannah, Georgia. The loss or gain of magnitude is not always proportional to the distance and I do not pretend to give it as a governing law. But in this case it is approximately correct.

In the eclipse of October 20th, 1892, the western limit was marked by a line running from Northwestern California to the Gulf of Tehauntepec.

If, therefore, we take our station at the western extremity of the boundary line between California and Oregon, we are where the eclipse is zero. Changing our station to Portland, Oregon, the magnitude of the eclipse becomes .08 and the duration 1^h 10^m; and going to Albany, New York, we find the magnitude 0.6 and the duration 3 hours.

Now, what causes these variations of magnitude and duration? Clearly, it is the Moon's parallax; and this changes for every place of observation. Not only does her parallax affect the magnitude and duration of a solar eclipse, but also the course of her path across the Sun's disc. This path is different, for different places; and hence a calculation of phases is necessary for each location of the observer.

Another very beautiful illustration of the Moon's parallax in solar eclipses is afforded by the eclipse limits on the meridian where the eclipse is central at noon. In every total or annular eclipse, there is always some place where the axis of the shadow lies in the plane of the meridian. At such a point the axis passes through the eye of the observer when both the Sun and Moon are on the meridian, and there we have "central eclipse at noon." The observer at this place sees the eclipse at its greatest magnitude; and if the eclipse is annular, the annulus appears in full splendor.

Having found the place of "central eclipse at noon," it is evident that if we travel south of this point, there will be some place where the eclipse fails. At such a place the Moon appears just north of the Sun; for in virtue of her parallax, she appears to move in a direction opposite to that in which we are travelling.

In like manner, there is a place north of the point of the central eclipse where the eclipse fails; and there the Moon appears to be just south of the Sun.

For example, in the solar eclipse of June 16, 1890, the eclipse was central at noon in latitude 36° 40′ N. and longitude 30° 31′ E. This place is in the southern part of Asia Minor. Here, at

the instant of apparent noon, the observer would have stood in line with the axis of the shadow. At the same instant, an observer, in latitude 75° 24′ N. and on the meridian of the central eclipse, would have seen the Sun and Moon in contact, the Moon being *south* of the Sun; while an observer in latitude 3° 53′ N. and on the meridian of the central eclipse would also have seen the Sun and Moon in contact, the Moon being *north* of the Sun. Between these limits the eclipse had all degrees of magnitude.

In lunar eclipses there is no variation of magnitude and duration for different places. Why?

Because, in lunar eclipses, the Moon actually passes into the Earth's shadow; and whatever change in direction the Moon may undergo by being seen from different stations, the shadow undergoes the same change. Hence, the Moon retains the same position relative to the shadow whatever may be the location of the observer. To return to our diagram. A ball in the middle of the window at D, appears just the same with respect to the window, seen from any part of the room. So a spot on the Sun, at the same instant, has the same position on the Sun's disc, whether seen from London or San Francisco. But the Moon being nearly 400 times nearer to us than the Sun, shifts her position with reference to the Sun for every station of observation. Hence the astronomer's vision of parallaxes in solar eclipses.

CHEHALIS, Lemis County, Wash.

STAR CLUSTERS.

ROGER SPRAGUE.

Among the many good things that have already appeared in POPULAR ASTRONOMY I have found but few which interested me more than Dr. Swift's "Suggestions to Amateurs." When I obtained the April number, the first thing which I turned to, after finishing Mr. Burnham's paper on double star orbits, was the article on "Nebulæ and Clusters." A good deal of originality is shown in the list of objects given, and I shall certainly examine Nos. 4 and 7 of said list at my earliest opportunity. But while I gained some new ideas, by reading Dr. Swift's article, I saw room for further remarks in the same line, and have accordingly prepared a brief list of clusters with which that much-advised individual, the amateur, could make himself familiar to good advantage.

No. 1. $7^h\ 14^m - 24°\ 44'$. This cannot be enjoyed with a telescope of less than 8 inches aperture. I picked it up accidentally with the 8-inch at Napa, Cal., while trying to catch the beautiful double star in $7^h\ 11^m - 23°\ 5'$. It consists of a brilliant star (magnitude 5.4) surrounded by a small flock of faint ones. The bright central star is followed by two faint companions at distances of 8″ and 15″. There was never any difficulty in seeing these with the 8-inch, and they added much to the interest with which visitors viewed the object, but with our 6-inch I am scarcely able to do anything with them.

No. 2. $7^h\ 36^m - 14°\ 32'$. This is a truly beautiful object, and is especially interesting on account of a small nebula which is here seen with the stars as a background. This beautiful contrasting of star-cluster and nebula makes this object specially valuable to one who is teaching a class in general astronomy. An 8-inch telescope, such as the high schools of Fall River, Mass., and Oakland, Cal., possess, brings out this object splendidly, but with a smaller glass, a careful adaptation of magnifying power to aperture is necessary in order that visitors may see the nebula at all. I find that a power of 100 diameters on our 6-inch shows it well.

No. 3. $15^h\ 12^m + 2°\ 32'$. M 5. A gorgeous object, comparable in beauty with the cluster in Hercules, M 13. It is of about the same brightness as the latter, being faintly visible to the naked eye. As it is about half way between Arcturus and the upper part of Scorpio, and is on a line with two stars to the west of it (109 and *t* Virginis), it can be readily found again after having been once located.

No. 4. $17^h\ 46^m - 34°\ 47'$. M 7. Visible to the naked eye. With the 8-inch refractor of Napa College Observatory, this was a favorite object among visitors, partly on account of its brilliancy. It is as bright to the naked eye as the Præsepe, and much more attractive in the telescope. It contains some 60 stars. A low power is necessary in viewing it, as it requires a field of 40′.

No. 5. $17^h\ 57^m - 24°\ 21'$. Visible to the naked eye. This is in the constellation of Sagittarius and is one of the most interesting objects in the whole sky on account of the intermingling of stars and nebulosity. We see in the field of view a bright nebulous mass which is intersected by several dark channels, and is followed by a coarsely scattered star cluster.

The objects mentioned in the above list are not much inferior for interest and beauty to those given by Dr. Swift. Nor does this list contain any of those time-worn and hackneyed objects towards which the telescope of any Observatory is usually directed on a public night.

Dr. Swift mentions the famous cluster in Hercules. This requires a rather higher power than most faint objects in order that it may be well seen. I have found a power of 25 diameters to the inch of aperture (200 for an 8-inch) to give the best results provided the altitude of the object was high. Many amateurs, and some professional astronomers as well, fall into the habit of doing all their star-gazing with one eyepiece, whereas a careful adaptation of magnifying power to object examined is as important in this sort of work as in any other. Four eyepieces, giving powers of from 7 to 25 diameters per inch of aperture, should be kept on hand for this sort of work. When any object is examined, it will be found that one of them will give a more pleasing view than any of the others.

Dr. Swift calls the cluster in Hercules one of the *six* visible to the naked eye. This number seemed to me to be a mistake and I have examined the matter sufficiently to find eight which can be seen by observers in the northern hemisphere, not to speak of others, as ω Centauri, which are reserved for southern observers. These eight are;—M 5, M 7, M 8, M 13, Præsepe, Pleiades, clusters in sword handle of Perseus, and a cluster in Argo Navis $7^h\ 31^m - 14°\ 12'$.

CHAMBERLIN OBSERVATORY,
Denver, April 7, 1894.

THE ETHER AND GRAVITATION.

BY W. H. S. MONCK.

The question whether gravitation is propagated by means of the ether which (so far as we know) occupies all space is one of no slight interest. The contrary—the instantaneous propagation of gravity—is supposed to be established on mathematical grounds. I plead guilty to never having studied Laplace's proof of the great rapidity of its transmission. But I always hesitate to accept a statement that some great mathematician has proved this or that in astronomy. I know enough of mathematics to be aware that pure mathematics can throw no light on such a subject. There must be physical data to start from or else we cannot make any progress at all. I also know enough of astronomy to be able to say that all our data have been greatly improved since Laplace's time, and therefore without questioning the accuracy of his mathematics I think I may entertain a

reasonable doubt as to the correctness of his conclusions. I may illustrate this by Professor Darwin's theory of the moon and the earth. The whole of his mathematical computation rests on the assumption that the earth possessed a particular degree of viscosity at the time. What evidence have we that it really possessed this degree of viscosity?

Sir Robert Ball's argument on the Ice Age strikes me as even more objectionable. He shows that when the Earth's orbit was more eccentric the total amount of solar heat was much more unequally distributed between summer and winter than at present. But instead of proving that this unequal distribution of heat would produce a permanent ice-cap he takes it for granted that it would do so—or else assumes that Dr. Croll's reasonings are satisfactory, which I think they are not. We could, I believe, reproduce the Ice Age at any moment if we could prevent our northern latitudes from receiving heat (by water or air) from the equatorial regions. But greater inequality of temperature would only produce stronger currents to and from the Equator.

So far my objections are of rather an abstract character and aim only at dispelling that unreasoning faith in supposed mathematical results which many astronomers entertain. But it seems to me that the theory of the instantaneous propagation of gravity has led to results which observation does not bear out except on the unproved hypothesis of undiscovered perturbing bodies. The motions of the Moon do not exactly conform to the present gravitation theory. Those of Mercury are even more astray. Periodic comets often depart both as regards the date of arrival and the orbit from the predictions of astronomers; and in the case of variable stars of the Algol type—eclipse stars—the present gravitation theory is rarely found to work satisfactorily without supposing a disturbance from some unknown cause. These last are the kind of cases which afford the best test of the instantaneous theory, for if there is a time propagation the variation in the direction of the acting force will as a rule be greatest when the revolution is most rapid. For this reason Mercury is the most likely body in the solar system to exhibit traces of time-propagation, excepting perhaps some of the inner satellites of the planets. The most probable mode of solving the problem however will be by means of careful observations on variables of the Algol type and spectroscopic double stars like β Aurigæ and Spica Virginis.

I may perhaps remark that Sir Isaac Newton believed that gravity acted through a medium from which its time-propaga-

tion follows almost as a matter of course. Subsequent research seems to have proved that a medium apparently suited for the purpose really exists. I hope some able mathematician will compute the effect of this time-propagation on the orbit of a binary star. We should of course remember that neither member of the pair is in the place where we see it. We see it where it was several years ago. As regards Mercury the matter rests on a somewhat different footing. No doubt we do not see Mercury and the Sun at the same moment, but the difference in time is inconsiderable. We do not see the Sun where it is but where it was a little more than eight minutes ago. Gravity unless propagated in time is never directed towards the center of the visible Sun.

One of my reasons for thinking that gravity is propagated in time is that collisions among the heavenly bodies occur so rarely, and that these bodies have not by this time been congregated into a comparatively small number of large masses. Collisions do not occur, I apprehend, because gravity never acts in the line joining the centres of gravity of two moving objects. The pull is not towards the place which the attracting body occupies now, but towards that which it occupied some time previously. For this reason even a very slow original motion at right angles to the joining line might suffice to avert a collision.

NEWTON'S COMET.

JOHN B. WOOD.

There are but four curves of motion admissible under the operation of the principle of gravitation. These are the circle, the ellipse, the parabola and the hyperbola, as proven by Sir Isaac Newton.

Theory had reached this conclusion before the comet of 1680, which is also known as Newton's Comet. Being of large size and visible for more than three months it quite naturally attracted attention, while its motions as observed by astronomers, had all the effect of an experiment which had been arranged to prove the Newtonian doctrine. Great must have been the influence of this apparition upon the minds of astronomers, while holding pause over the gravitation philosophy of Newton.

According to a determination of the orbit made by Encke we are enabled to represent it after the following manner. Our scale of distance is one inch for the radius of the Earth's orbit treated

as a circle. We select wire one-hundredth of an inch thick, to make a model of the comet's path, the outside of the wire being the line of its motion. Our ellipse will be over seventy feet measured lengthways but not five inches across its width. The Sun would be at one end of the line of length, in the substance of the wire.

When the comet was nearest the Sun it had been falling to it for some 4300 years in its real curve, having the shape of our excessively elongated wire ellipse. It can be seen that the solar pull for most of the time was almost as if the line of approach were a straight one pointed for the solar center. Its velocity therefore was almost entirely due to the accumulated pulls exerted from second to second for this long time. The speed at perihelion was over 327 miles a second. In aphelion the rate of motion will be less than 16 feet in the same time.

From this supposed model two lessons can be learned. That astronomers should not agree as to whether an orbit is a parabola or an ellipse or as to whether it is an ellipse of one length or another, will no longer seem a reproach to them; for only in the very small part of the curve near the Sun, say at the most some five inches on our scale, is the comet visible. And as absolute accuracy in the places of the comet is unattainable the real departure from the supposed curve may be of such nature as to change the magnitude and even the character of the curve.

Also, as the time of revolution depends on the long axis, a very small error near by may count for very much out in space. So that instead of a short period we may really be dealing with a very long one. Or perhaps, contrary to prediction, the comet may move in a parabola and never return.

This is seen in the case of our comet. One estimate makes its time some 8700 years. According to Halley, Newton's Comet is to be identified with that of about 43 B. C. of 531 A. D. and of 1106, A. D. which would make its period some 574 years. Professor Mitchell observes concerning it that a parabolic orbit fitted the observations and that its period was nearly six hundred years.

THE CARE OF THE TELESCOPE.*

As a valuable and delicate instrumeut the telescope demands, and should receive, the most solicitous care. In particular does

* From the Amateur Telescopist's Hand-book by Frank M. Gibson.

the object glass require the most tender treatment. It should be kept covered with its cap whenever it is not in actual use; the dew-cap should never be forgotten; and the glass should never be brought from a cold into a warm atmosphere without first covering it to prevent its becoming bedewed. If the damp gets between the glasses it will produce a fog—a *sweat*, in optician's language—and, according to Proctor, even a seaweed-like vegetation, by which a valuable glass may be ruined. Should any moisture unluckily get upon the object glass, the telescope must be put in a warm place until the enemy has fled.

When it is necessary to clean the object glass—and it should only be touched when cleaning *is* necessary—a soft camel's-hair brush should first be used for removing the coarser particles of dust, which may be followed by a very careful sweeping with either a piece of very fine clean chamois-skin, or, better still, an old soft silk handkerchief. Mr. Franks recommends soft tissue paper aided by the breath. A little space near the edge of the glass is first cleaned, and from that point the dust is gently swept away. But let it be noted that a few specks of dust are of much less moment than irremediable scratches, and polished optical glass scratches very easily. Should any "refractory stains" get upon the object glass, they may be removed by a few drops of alcohol on perfectly clean absorbent cotton; but, as Mr. Chambers dryly observes, a careful observer will never allow any refractory stains to get upon his object glass. Should fine dust ever cake, as it sometimes will, upon the glass, breathe on it and wipe very gently from the edges with a soft cloth, which is then thrown away. This may sound alarming, but it is the precept of no less high an authority than Sir Howard Grubb.

Everything used for cleaning lenses should be kept in a tightly closed box when not in use, to preserve it from dust.

Never touch the polished surface of any lens with your fingers. The insensible perspiration, always present in small quantities, appears to have a corroding effect upon optical glass, and will destroy its polish.

All of the foregoing remarks as to cleaning lenses apply to eyepieces as well as to object glasses. Particularly must it be remembered that every scratch or speck on the field glass of a negative eyepiece will appear in a magnified form on looking through the eyeglass. Eyepieces should be kept, when not in use, in a dust-tight box; one provided with compartments is by far the best.

Under no circumstances should the two glasses composing the

objective be separated or taken out of their cell by the amateur. Should circumstances make it necessary to separate them, let it be done by the maker or by a competent optician: otherwise the glass may be rendered worthless. Another rule, with an example is given by Mr. Proctor, which I will quote in his own vigorous language: "Suffer no inexperienced person to deal with your object glass. I knew a valuable glass ruined by the proceedings of a workman who had been told to attach three pieces of brass round the cell of the double lens. What he had done remained unknown; but ever after a wretched glare of light surrounded all objects of any brilliancy."

Should the brass-work of the telescope or stand become dull or dirty, it may be cleansed with a piece of chamois-skin moistened with sweet-oil. Care should be taken in cleaning an equatorial stand, not to press hard upon the circles lest they be bent out of "true." For protecting bright metal surfaces from oxidation, and also for lubricating purposes, ordinary vaseline is by far the best preparation, as it is free from the gumminess which is apt to attach to common oils.

METEORS AND STELLAR SCINTILLATION.

S. E. CHRISTIAN.

It seems to me that stellar scintillation is largely caused by occultations of the stars by small meteoric bodies passing between them and ourselves.

Lord Rayleigh in his excellent article on this subject admits that it is difficult to see how that atmospheric disturbances could take place suddenly enough to produce such sudden results.

The opposite temperatures of the atmosphere producing no difference in scintillation seems to be another difficulty in the theory of "atmospheric disturbances."

Both of these difficulties are easily overcome when we consider scintillations to be only momentary occultations of the stars by opaque bodies revolving either around the Sun or around the Earth outside of the atmosphere.

Of course if we account for it in this way it is necessary to admit of almost inconceivable numbers of these bodies continually passing between ourselves and the stars: but in the light of recent investigation such an admission is quite easy.

Sufficient numbers of these bodies, once admitted, it is easy to see what results would follow; momentary occultations precisely such as we see in scintillations would really be unavoidable.

I think it is quite probable that immense swarms of these small bodies continually revolve around the Earth at no very great distance from the atmosphere or at least inside of the orbit of the Moon. Immense swarms of them we know, revolve around the Sun, and as we see the satellites revolving around the planets, corresponding to the planetary revolutions around the Sun, we see no good cause why these swarms of meteors should not also have their corresponding swarms revolving around the planets. In fact we really know this to be the case in regard to Saturn. Why not then use analogy again to prove that other planets have or at least may have, corresponding swarms, though of course of more tenuity than those of Saturn. Telescopes of course could never render them visible and our only means of becoming sensible of their presence there would be the momentary occultations that they would cause in the tiny points of light from the stars, producing scintillations.

It is not necessary, however, we think, to show that these bodies really revolve around the Earth to produce this phenomena—sufficient numbers revolving around the Sun would be sufficient—even bodies outside of the solar system would produce the same effect if sufficiently large. The increase in the scintillations of stars near the horizon seems to show that the cause, whatever it may be, is situated, at least in part, at no very great distance from the Earth. It might be possible however to account for this differently, as very small bodies might cause many partial occultations that would only be noticeable under certain favorable conditions offered near the horizon. What seems to offer more proof of these partial occultations is the increase in the scintillation of stars when viewed through a good glass. I think this is because many partial occultations that are not noticeable by the naked eye become apparent when viewed through a good glass.

The difference in scintillation between different stars, although hard to reconcile with any theory, is somewhat accounted for by this theory, from the fact that although the stars being mere points of light have no apparent disk, yet theoretically it would certainly be easier to raise a disk on some of them than it would on others, so that a small body that would be sufficient to totally occult some of them would only partially occult others.

Before closing I would say that some information might be gained by a careful observation of stars when in the immediate neighborhood of the planets. If any increase could be found in their scintillation there it would evidently be the result of metoric bodies revolving around the planets. However the small size of these bodies might not be sufficient at that distance to produce any perceptible occultations, even if their close proximity to the planets should not interfere with a proper observation. However I think it would pay to try, and if any one should do so I would be pleased to hear the result.

OCEANA, W. Va.

PLANET NOTES FOR JUNE.

H. C. WILSON.

Mercury will be "evening star" during June. On the 22d he will be at his greatest distance (elongation) east from the Sun, and will set about an hour and a half later than that body. This month will be a good time both for daylight and evening observations of this planet. Its phase will be gibbous during the first half and crescent during the last half of the month. The moon will pass by Mercury on the evening of June 4, conjunction in right ascension occurring at $10^h\ 32^m$ central time.

Venus will be "morning star" rising about two hours before the Sun. She is getting around toward the farther side of her orbit so that her brightness is decreasing considerably. At the same time her phase is becoming more gibbous. At the beginning of the month 0.67 and at the end 0.76 of her disc will be illuminated.

Considerable has been said lately about the dark part of the disc of Venus being visible, just as the dark part of the new Moon is visible. Several observers claim to have seen the complete outline of Venus' disc a few days before she disappeared in the rays of the Sun this past winter, when her crescent was very narrow. We may say, I think, that this visibility is not from the same cause that renders the dark part of the moon visible, viz.: reflected earthshine. Venus is more than 100 times as far as the Moon from the Earth and therefore would receive less than the ten-thousandth part of the light thrown upon the Moon. The most probable explanation is that Venus has a dense atmosphere, possibly more extensive than that of the Earth, so that her twilight is longer, and extends far enough into the dark hemisphere to become visible from the Earth as a complete ring of light when the crescent of direct illumination is small. The observer discerning the outline of the dark part of the planet, by this faint ring, would naturally have the impression of seeing it all.

Mars will be at quadrature, 90° west from the Sun, June 17, and will be in position to be observed after midnight during this month. Mars will move northeast during June, from Aquarius across a little corner of Pisces into Cetus. The phase of the planet will be smaller this month than at any other time in the year, only 0.84 of the disc being illuminated. Mars will be in conjunction with the Moon, about 3° south of the latter, 48^m after midnight, June 25.

Jupiter and *Neptune* are not to be seen during June.

Saturn is making the turn of the loop in his apparent path among the stars of Virgo. He will begin to move eastward after June 21. The amateur should not fail to make the most of these summer months in the study of this planet. The surface markings on so bright a planet are almost as likely to be seen with a small telescope as with a large one. The Moon will pass by Saturn, 4° south of the latter, June 12, at $2^h\ 41^m$ P. M. central time.

Uranus will be in his most convenient situation for observation during June, being near the meridian during the evening hours. He ought to be easily found by means of stars α and μ Libræ (see Poole Bros. map). Look about 1° 30′ west and 30′ north, *i. e.*, 3 diameters of the Moon west and 1 diameter north, of α, for a star with a dull green disc a little brighter than the star μ.

Planet Tables for June.

[The times given are local time for Northfield. To obtain Standard Times for Places in approximately the same latitude, add the difference between Standard and Local Time if west of the Standard Meridian or subtract if east].

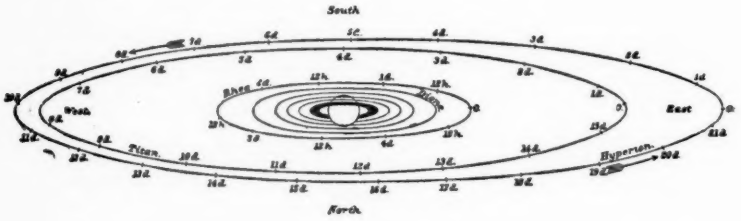
Date. 1894.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
MERCURY.					
June 5.....	6 12.1	+25 31	5 19 A. M.	1 15.3 P. M.	9 11 P. M.
15.....	7 20.7	+23 47	5 58 "	1 44.4 "	9 31 "
25.....	8 05.7	+20 21	6 21 "	1 50.0 "	9 19 "
VENUS.					
June 5.....	2 04.5	+10 13	2 24 A. M.	9 08.3 A. M.	3 53 P. M.
15.....	2 48.2	+13 49	2 13 "	9 12.6 "	4 12 "
25.....	3 33.9	+17 01	2 05 "	9 18.8 "	4 32 "
MARS.					
June 5.....	23 20.7	− 6 51	12 49 A. M.	6 25.0 A. M.	12 01 P. M.
15.....	23 45.6	− 4 26	12 24 "	6 10.5 "	11 56 A. M.
25.....	0 09.6	− 2 03	12 00 "	5 55.2 "	11 50 "
JUPITER.					
June 5.....	4 51.5	+22 03	4 17 A. M.	11 55.0 A. M.	7 33 P. M.
15.....	5 01.4	+22 19	3 46 "	11 25.5 "	7 04 "
25.....	5 11.2	+22 32	3 16 "	10 56.0 "	6 36 "
SATURN.					
June 5.....	13 12.7	− 4 50	2 30 P. M.	8 14.7 P. M.	1 59 A. M.
15.....	13 12.0	− 4 49	1 50 "	7 34.7 "	1 19 "
25.....	13 11.9	− 4 51	1 11 "	6 55.3 "	12 40 "
URANUS.					
June 5.....	14 38.8	− 15 04	4 38 P. M.	9 40.6 P. M.	2 43 A. M.
15.....	14 37.7	− 14 59	3 57 "	9 00.1 "	2 03 "
25.....	14 36.7	− 14 55	3 17 "	8 19.9 "	1 23 "
NEPTUNE.					
June 5.....	4 48.4	+20 58	4 20 A. M.	11 51.9 A. M.	7 24 P. M
15.....	4 49.9	+21 01	3 42 "	11 14.2 "	6 57 "
25.....	4 51.5	+21 04	3 04 "	10 36.3 "	6 09 "
THE SUN.					
June 5.....	4 54.9	+22 37	4 17 A. M.	11 58.3 A. M.	7 40 P. M.
15.....	5 36.3	+23 21	4 15 "	12 00.3 P. M.	7 46 "
25.....	6 17.9	+23 23	4 17 "	12 02.4 "	7 48 "
THE MOON.					
June 2.....	3 25.6	+22 32	2 54 A. M.	10 41.0 A. M.	6 45 P. M.
4.....	5 41.3	+28 19	4 19 "	12 48.4 P. M.	9 22 "
6.....	8 01.7	+25 22	6 41 "	3 00.6 "	11 06 "
8.....	10 03.7	+15 22	9 27 "	4 54.5 "	12 05 A. M.
10.....	11 47.0	+ 2 31	12 00 M	6 29.6 "	12 45 "
12.....	13 22.8	− 10 09	2 21 P. M.	7 57.2 "	1 21 "
14.....	15 01.3	− 20 37	4 40 "	9 27.8 "	2 06 "
16.....	16 48.3	− 27 04	6 56 "	11 06.5 "	3 13 "
18.....	18 40.3	− 28 08	8 49 "	12 50.3 A. M.	4 54 "
20.....	20 27.6	− 23 43	10 05 "	2 28.5 "	6 59 "
22.....	22 05.1	− 15 04	10 56 "	3 58.9 "	9 12 "
24.....	23 36.0	− 3 46	11 32 "	5 21.7 "	11 24 "
27.....	1 09.0	+ 8 36	12 07 A. M.	6 46.5 "	1 41 P. M.
29.....	2 55.4	+20 13	12 50 "	8 24.8 "	4 16 "

Occultations Visible at Washington.

Date 1894	Star's Name.	Magnitude.	IMMERSION Washington M. T.	IMMERSION Angle from N p't.	EMERSION Washington M. T.	EMERSION Angle from N p't.	Duration.
			h m	°	h m	°	h m
June 15	3 Scorpii.....	7	7 38	150	8 46	267	1 08

Elongations of the Satellites of Saturn.

[In the diagram the points marked 0 are those of eastern elongation of the several satellites. Their positions at intervals of one day after eastern elongation are indicated by the symbols 1*d*, 2*d*, etc].



MIMAS.

		h		
June	2	12.3	A. M.	W
	2	10.9	P. M.	W
	3	9.5	"	W
	4	8.1	"	W
	5	6.7	"	W
	6	4.3	"	W
	7	2.9	"	W
	8	1.5	"	W
	9	1.9	A. M.	E
	10	12.5	"	E
	10	11.1	P. M.	E
	11	9.8	"	E
	12	8.4	"	E
	13	7.0	"	E
	14	5.6	"	E
	15	4.2	"	E
	16	2.8	"	E
	18	12.8	A. M.	W
	18	11.4	P. M.	W
	19	10.0	"	W
	20	8.6	"	W
	21	7.2	"	W
	22	5.8	"	W
	23	4.4	"	W
	24	3.0	"	W
	25	1.6	"	W
	26	11.7	"	E
	27	10.3	"	E
	28	8.9	"	E
	29	7.5	"	E
	30	6.1	"	E

ENCELADUS.

		h		
June	1	7.0	P. M.	E
	3	3.9	A. M.	E
	4	12.7	P. M.	E
	5	9.6	"	E
	7	6.5	A. M.	E
	8	3.4	P. M.	E
	10	12.2	A. M.	E

ENCELADUS Cont.

		h		
June	11	9.1	A. M.	E
	12	6.0	P. M.	E
	14	2.9	A. M.	E
	15	11.8	"	E
	16	8.7	P. M.	E
	18	5.5	A. M.	E
	19	2.4	P. M.	E
	20	11.3	"	E
	22	8.2	A. M.	E
	23	5.1	P. M.	E
	25	1.9	A. M.	E
	26	10.8	"	E
	27	7.7	P. M.	E
	29	4.6	A. M.	E
	30	1.5	P. M.	E

TETHYS.

		h		
June	2	11.5	P. M.	E
	4	8.8	"	E
	6	6.0	"	E
	8	3.3	"	E
	10	12.6	"	E
	12	9.9	A. M.	E
	14	7.2	"	E
	16	4.5	"	E
	18	1.8	"	E
	19	11.1	P. M.	E
	21	8.4	"	E
	23	5.7	"	E
	25	3.0	"	E
	27	12.3	"	E
	29	9.6	A. M.	E

DIONE.

		h		
June	2	12.7	A. M.	E
	4	6.4	P. M.	E
	7	12.1	"	E
	10	5.8	A. M.	E
	12	11.4	P. M.	E

DIONE Cont.

		h		
June	15	5.1	A. M.	E
	18	10.8	A. M.	E
	21	4.5	"	E
	23	10.1	P. M.	E
	26	3.8	"	E
	29	9.5	A. M.	E

RHEA.

		h		
June	5	5.9	A. M.	E
	9	6.3	P. M.	E
	14	6.7	A. M.	E
	18	7.0	P. M.	E
	23	7.4	A. M.	E
	27	7.8	P. M.	E

TITAN.

		h		
June	3	7.0	P. M.	I
	7	9.9	"	W
	12	12.4	A. M.	S
	15	7.4	P. M.	E
	19	5.1	"	I
	23	8.0	"	W
	27	10.5	"	S

HYPERION.

		h		
June	3	5.8	P. M.	E
	10	2.0	A. M.	I
	15	8.7	"	W
	19	6.2	P. M.	S
	24	11.6	"	E
July	1	8.9	A. M.	I

IAPETUS.

		h		
May	17	4.3	P. M.	W
June	6	3.7	A. M.	S
	26	4.0	P. M.	E
July	14	5.3	"	I

Elongations of the Satellites of Uranus.

[The diagram shows the apparent paths of the satellites of Uranus during the summer of 1894. The black dots with the numerals indicate the positions of the satellites at intervals of 1 day after each northern elongation. The points marked 0 are those of northern elongation.]

ARIEL.

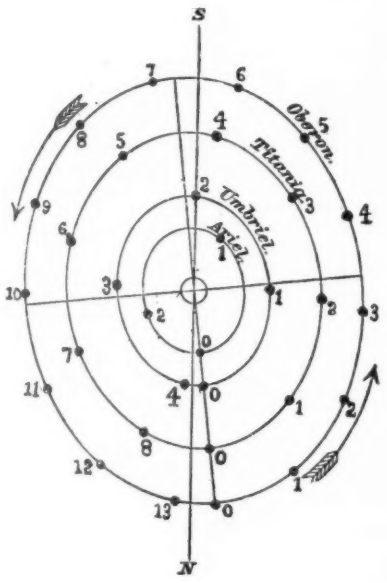
		h	
June	2	5.0 P. M.	N
	5	5.5 A. M.	N
	7	6.0 P. M.	N
	10	6.4 A. M.	N
	12	6.9 P. M.	N
	15	7.4 A. M.	N
	17	7.9 P. M.	N
	20	8.4 A. M.	N
	22	8.9 P. M.	N
	25	9.3 A. M.	N
	27	9.8 P. M.	N
	30	10.3 A. M.	N

UMBRIEL.

		h	
June	1	9.8 P. M.	N
	6	12.4 A. M.	N
	10	3.9 "	N
	14	7.3 "	N
	18	10.8 "	N
	22	2.3 P. M.	N
	26	5.8 "	N
	30	9.2 "	N

TITANIA.

		h	
June	2	7.3 A. M.	N
	6	3.8 P. M.	S
	11	12.2 A. M.	N
	15	8.7 "	S
	19	5.2 P. M.	N
	24	1.5 A. M.	S
	28	10.2 "	N



OBERON.

		h	
June	3	8.3 A. M.	S
	10	1.9 "	N
	16	7.6 P. M.	S

OBERON CONT.

		h	
June	23	1.2 P. M.	N
	30	6.8 A. M.	S

Maxima and Minima of Variable Stars.

[From ephemerides by Dr. Loewy in the "Companion to the Observatory," and by Dr. Hartwig in the "Vierteljahrsschrift der Astronomische Geselischaft".]

		MAXIMA			MAXIMA			MINIMA
June	1	R Leonis	June	19	R Lyræ	June	4	R Virginis
	1	W Hydræ		19	S Camelopardi		4	R Lyræ
	2	S Aquarii		19	S Libræ		6	R Vulpeculæ
	2	V Virginis		22	R Lyncis		6	V Cephei
	3	V Coronæ		23	X Boötis		9	R Draconis
	3	R Cygni		23	V Boötis		13	X Libræ
	5	R Scuti		24	R Cassiopeiæ		13	W Herculis
	6	R Aquilæ		25	R T Cygni		14	U Piscium
	7	R Sagittæ		26	S Pegasi		15	X Cygni
	8	S Boötis		26	V Libræ		20	T Aquarii
	12	Z Cygni		29	Z Libræ		21	S Geminorum
	13	U Herculis		30	U Geminorum		22	X Ophiuchi
	17	V Cancri					23	R Hydræ
	17	U Monocerotis					29	S Vulpeculæ

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Central Standard Time.]

U CEPHEI.

		h	
June	2	12	M.
	4	12	midn.
	8	12	M.
	10	12	midn.
	13	11	A. M.
	15	11	P. M.
	18	11	A. M.
	20	11	P. M.
	23	11	A. M.
	25	11	P. M.
	28	10	A. M.
	30	10	P. M.

S CANCRI.

June	9	10	A. M.
	18	9	P. M.
	28	9	A. M.

δ LIBRÆ.

June	2	8	A. M.
	4	3	P. M.
	6	11	"
	9	7	A. M.
	11	3	P. M.
	13	11	"
	16	7	A. M.
	18	2	P. M.
	20	10	"
	23	6	A. M.
	25	2	P. M.
	27	10	"
	30	6	A. M.

U CORONÆ.

June	1	7	P. M.
	5	6	A. M.
	8	5	P. M.
	12	4	A. M.
	15	3	P. M.
	19	2	A. M.
	22	12	M.
	25	11	P. M.
	29	10	A. M.

U OPHIUCHI.

June	1	12	M.
	2	8	A. M.

U OPHIUCHI Cont.

June	3	4	A. M.
	3	12	midn.
	4	8	P. M.
	5	4	"
	6	12	M.
	7	8	A. M.
	8	5	"
	9	1	"
	9	9	P. M.
	10	5	"
	11	1	"
	12	9	A. M.
	13	5	"
	14	1	"
	14	10	P. M.
	15	6	"
	16	2	"
	17	10	A. M.
	18	6	"
	19	2	"
	19	10	P. M.
	20	7	"
	21	3	"
	22	11	A. M.
	23	7	"
	24	3	"
	24	11	P. M.
	25	7	"
	26	4	"
	27	12	M.
	28	8	A. M.
	29	4	"
	29	12	midn.
	30	8	P. M.

Y CYGNI.

June	1	12	midn.
	3	12	M.
	4	12	midn.
	6	11	A. M.
	7	11	P. M.
	9	11	A. M.
	10	11	P. M.
	12	11	A. M.
	13	11	P. M.

Y CYGNI Cont.

		h	
June	15	11	A. M.
	16	11	P. M.
	18	11	A. M.
	19	11	P. M.
	21	11	A. M.
	22	11	P. M.
	24	11	A. M.
	25	11	P. M.
	27	11	A. M.
	28	11	P. M.
	30	11	A. M.

S ANTLIÆ.

(Every third minimum.)

June	1	11	A. M.
	2	10	"
	3	9	"
	4	9	"
	5	8	"
	6	7	"
	7	7	"
	8	6	"
	9	5	"
	10	5	"
	11	4	"
	12	3	"
	13	3	"
	14	2	"
	15	1	"
	16	1	"
	17	12	midn.
	17	11	P. M.
	18	11	"
	19	10	"
	20	9	"
	21	9	"
	22	8	"
	23	7	"
	24	7	"
	25	6	"
	26	5	"
	27	5	"
	28	4	"
	29	3	"
	30	3	"

Phases and Aspects of the Moon.

Central Time.

		d	h	m	
New Moon	June	3	4	56	P. M.
Perigee	"	4	11	40	P. M.
First Quarter	"	10	7	14	A. M.
Full Moon	"	18	1	06	A. M.
Apogee	"	20	4	50	A. M.
Last Quarter	"	26	4	03	A. M.

COMET NOTES.

Discovery of a New Comet (*a* 1894, Denning).—A telegram from Mr. John Ritchie, Jr., Boston, March 28, announced the discovery of a faint comet by Mr. W. F. Denning of Bristol, England, the following being the discovery position:

March 26.396 Gr. M. T. R. A. $9^h\ 55^m$. Decl. $+ 32°\ 15'$.

The comet was observed at Northfield on the evening of March 28, and found to be a very small object, very difficult to see in the 5-inch finder, but easily seen and measured with the 16-inch telescope. It had a well defined nucleus of the 11th magnitude, with nebulosity surrounding it between 1′ and 2′ in diameter. It had a short, slightly spreading tail, 2′ or 3′ long. From our own observations on the dates March 28, April 1, and April 5, we have computed the following parabolic elements of the comet's orbit:

	Time of perihelion	= 1894 Feb. 14.1900 Greenwich mean time.
π	= Longitude of perihelion	= 133° 26′ 15″
Ω	= Longitude of node	= 75 34 12 } Mean equinox 1894.0
i	= Inclination	= 6 31 06
q	= Perihelion distance	= 1.22497.

These elements do not represent the middle place, the observation of April 1, with a sufficient degree of accuracy, the outstanding residuals being + 8″ in longitude and + 26″ in latitude. These residuals cannot be reduced on any assumption of a parabolic orbit, and it may be presumed that the orbit will turn out to be an ellipse of comparatively short period.

As the comet is growing rapidly fainter it is not probable that those using small telescopes will see it. We therefore give the following ephemeris only to indicate approximately the course of the comet and its increasing distance from us. Its path among the stars during April and May, is shown upon Poole Bros' Map in this number.

EPHEMERIS OF COMET *a* 1894.

		R. A. h	m	s	Decl. °	′	log Δ	log r	Br.
Mar.	28	10	02	24	+ 31	01	9.7080	0.1421	1.00
Apr.	5	10	28	36	26	44	9.7632	0.1605	0.71
	13	10	50	16	22	44	9.8201	0.1799	0.50
	21	11	08	28	19	05	9.8778	0.1999	0.35
	29	11	24	36	15	47	9.9345	0.2201	0.25
May	7	11	39	08	12	48	9.9895	0.2403	0.17
	15	11	52	24	10	07	0.0428	0.2601	0.12
	23	12	05	04	7	40	0.0933	0.2797	0.09
	31	12	16	08	+ 5	33	0.1385	0.2965	0.07

A New Comet Discovered in Australia.—A telegram from Mr. John Ritchie April 6 announced the discovery of a comet by Mr. Gale at Sydney, Australia. The discovery position was:

April 2.944 Gr. M. T. R. A. $2^h\ 30^m\ 48^s$; Decl. $- 55°\ 35'$.

The motion is easterly. The comet is described as round with a bright condensation. This comet is too far south to be visible at any of the northern Observatories.

A Comet's Tail Discovered by Holmes.—Another telegram received April 11, announces the discovery of a bright comet's tail by Holmes April 9. Its approximate R. A. and Decl. were $17^h\ 58^m$ and $+ 71°\ 30'$.

Ephemeris of Tempel's Second Periodic Comet (1873 II).—Mr. L. Schulhof gives an ephemeris of this comet, in *Astronomische Nachrichten*, No. 3219, for the month May 19 to June 16. The elements used are as follows:

Epoch and osculation: 1894, April 25.0 Paris mean time.

$M = 0° 15' 27''$			$\varphi = 36° 26' 34''$
$\pi = 306 14 22$	}		$\mu = 679''.860$
$\Omega = 121 10 02$	}	1894.0	$\log a = 0.478392$
$i = 12 44 20$	}		

At the time of the last observation of this comet in 1878 its brightness was somewhat less than that which it should be theoretically during this month. It is therefore to be hoped that the comet will be found at this apparition.

EPHEMERIS.

		R. A.			Decl.		$\log \Delta$	$1 : r^2\Delta^2$
		h	m	s	°	′		
May	19	0	18	39	− 2	48.6	0.22119	0.190
	20		21	43	2	37.5		
	21		24	46	2	26.6	0.22049	
	22		27	48	2	15.7		
	23		30	50	2	04.9	0.21982	0.188
	24		33	50	1	54.2		
	25		36	50	1	43.6	0.21917	
	26		39	49	1	33.1		
	27		42	47	1	22.7	0.21853	0.186
	28		45	44	1	12.4		
	29		48	40	1	02.3	0.21791	
	30		51	35	0	52.3		
	31		54	30	0	42.3	0.21730	0.184
June	1	0	57	24	0	32.5		
	2	1	00	16	0	22.8	0.21670	
	3	1	03	07	0	13.3		
	4		05	58	− 0	03.9	0.21611	0.182
	5		08	48	+ 0	05.4		
	6		11	37	0	14.5	0.21552	
	7		14	25	0	23.5		
	8		17	11	0	32.3	0.21492	0.179
	9		19	56	0	41.0		
	10		22	41	0	49.6	0.21432	
	11		25	25	0	58.0		
	12		28	08	1	06.3	0.21371	0.177
	13		30	50	1	14.4		
	14		33	31	1	22.4	0.21309	
	15		36	11	1	30.2		
	16	1	38	49	+ 1	37.9	0.21246	0.174

Mr. Schulhof says that the uncertainty of the time of perihelion passage can not be more than ± 2 days. Should this occur two days early the R. A. of the comet would be increased $3^m 35^s$ May 15 and $2^m 55^s$ June 16, and the declination would be increased 10′ May 15 and 11′ June 16. If the perihelion passage should be 2 days later than calculated the R. A. would be decreased $3^m 43^s$ May 15 and and $3^m 02^s$ June 16, and the Decl. decreased 10′ May 15 and 11′ June 16. The observer searching for the comet may need to sweep over a space 20′ wide, extending 1° each way, east and west, from the predicted place of the comet.

Comet *b* 1894 (Gale).—From Science Observer Circular No. 105, we take the following:—A later message received April 15, contained the elements as given below, which were computed by Kreutz. From these an ephemeris has been computed by the Rev. G. M. Searle, which is given below.

ELEMENTS.

$T = 1894$ April 13.82 Greenwich M. T.
$\omega = 324°\ 18'$
$\Omega = 206\ \ 9$ } Mean Eq. 1894.0
$i = 87\ \ 24$
$q = .9856$

EPHEMERIS FOR GREENWICH MIDNIGHT.

	R. A.			Decl.		Light.
	h	m	s	°	′	
April 28	7	14	40	− 27	35	5.47
May 2	8	5	28	− 11	36	
6	8	47	32	+ 2	44	
10	9	21	0	+ 15	15	3.21

Light, April 2 = 1.

The object announced as a new, bright comet, by Holmes, in the position, R. A. $17^h\ 58^m$, Decl. + 71° 30′, proves not to have been a comet.

The comet discovered by Denning on March 26 was observed here the next night, March 27, 8 hours 75 Meridian time, in approximate position, R. A. $9^h\ 58^m$ + 31° 29′. It was an easy object in the 10-inch refractor, having a very small but sharply defined nucleus, so close to the edge of the nebulosity that it was somewhat doubtful at first sight whether it belonged to the comet or was a star. A few minutes watching showed that it was a part of the comet. From the stellar nucleus extended a short, broad fan-shaped tail. Many fruitless searches were made here for the bright comet reported to be discovered by Holmes, of England on April 9. As neither direction or rate of motion were given in the announcement, a large region of the sky in the place indicated was swept over until it became evident that some mistake had been made by Mr. Holmes, and this, I have just learned, was really the case. This experience emphasises once more the importance of *always ascertaining motion* beyond the possibility of a doubt before making a public announcement. If this is not possible at discovery, then the suspected comet should be telegraphed to some leading observatory, preferably to Harvard by American observers, with instruction to with hold the public announcement until verified by the observation of motion, either at the observatory so notified, or by the discoverer himself. This simple precaution would often save the very considerable expenditure of a world wide announcement, and what is often of far greater importance, the waste of many hours of valuable time. To all of us, at times, a *clear night* is above riches.

WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y., April 18, 1894.

A man weighing 12 stone on the Earth would, if transported to the surface of the Sun, weigh no less the than two tons! and would be wholly unable to sustain his own weight. A certain insect which possesses enormous muscular power in proportion to its weight might be able to move about with much difficulty; but all the larger animals would at once be deprived of their powers of locomotion. A projectile from even a Hotchkiss gun would be utterly useless on the Sun, as owing to the increased force of gravity it would be rapidly drawn to its surface, and its range would be reduced to only a few yards from the cannon's mouth.—Gore in "Scenery of the Heavens."

PRACTICAL SUGGESTIONS.

34. I would like to know where I can find something of the work of the Lick telescope, its powers and possibilities? C. R. P.

Answer: A description of Lick Observatory and its instruments including the large telescope, of course, is given in the Hand-book of the Lick Observatory, published by Professor E. S. Holden, the director, some years ago. The powers of the instrument are known in theory by the size of the object glass and the eye-pieces it will carry in doing different kinds of astronomical work, and in practice, by the use of such tests. The defining power has been shown in revealing very minute details on the Moon's surface, in the discovery of faint new stars in the Trapezium of Orion, in the details of faint nebulæ, the surface markings of planets, in the discovery of the 5th satellite of Jupiter, in the separation of very faint double stars, and other difficult visual work. The great instrument has an equally interesting record in the lines of photographic and spectroscopic investigation. Its light-gathering power has given it great advantage in the study of faint celestial objects. For a few years past it has been the court of last resort in the decision of hard astronomical questions. It would be impossible to point to any one source for information in regard to all the important work accomplished by the great Lick telescope. There is not an important magazine in this country or Europe that has not given something of its work or power during the last five years. Professor Holden is a very able and a very ready writer, and the calls on him, from every part of the civilized world, for information and help in astronomical work have been simply enormous. On this account the literature pertaining to the Lick Observatory has been very widely scattered. In a more formal way it will be found in the publications of the Observatory, the publications of Astronomical Society of the Pacific, in volumes of the *Sidereal Messenger*, volumes XI and XII of *Astronomy and Astro-Physics*, in the *Astronomical Journal*, *Nachrichten*, *Knowledge* and the *Journal of the British Astronomical Association*. It is also true that much of the work of the great telescope is not yet published, because yet in course of observation or reduction.

35. What are the possibilities of the unfinished Yerkes telescope? C. R. P.

Answer: It is yet too early to say much about the Yerkes telescope. Its great objective is quite finished though not yet turned over to the authorities of the new Observatory. The mounting by Messrs. Warner & Swasey was completed nearly a year ago and was exhibited at the World's Fair in Chicago last summer. For brief description of it see *Astronomy and Astro-Physics*, Vol. XII, page 571, Vol. XI, page 790.

36. When the classical writers speak of a star or constellation as rising at a certain time of the year, is it the *heliacal* which is referred to? C. F. T.

Answer: The ancients had no telescopes. The horizon was the only scientific instrument they possessed. They spoke of the stars as rising cosmically, achronically and heliacally. Cosmic rising was at the same moment with the Sun. Achronical rising of a star was at the time of the Sun setting, and heliacal rising of a star was in advance of the rising of the Sun. The term "heliacal" rising was coined to represent a star rising visibly in the dawn, therefore before the Sun. Generally throughout Egypt the Sun was supposed to be something like 10° below the horizon when a star was stated to rise "*heliacally*." A good chapter on this theme will be found in *Lockyer's Dawn of Astronomy*, published

by Macmillan & Co., New York, 1894. The early writers used these three different kinds of the risings of the stars. Bright stars only could have been seen in the case of cosmic or achronic rising, in heliacal rising fainter stars could also be seen. It is very probable that the latter rising was generally referred to by the classic writers.

37. When the approximate position of the Moon in the heavens is given in almanacs, etc., is the zodiacal constellation or zodiacal sign meant? C. F. T.

Answer: The latter.

38. When astrology was in vogue, was it customary in casting a horoscope to employ zodiacal constellations or zodiacal signs? C. F. T.

Answer: The groups of stars we now call constellations were formerly called signs, especially those of the zodiac and others adjacent. It was not until about the first century before Christ that the signs of the zodiac as distinguished from the constellations of the zodiac were used. They were introduced by Hipparchus because the groups of asterisms, now called constellations, were too indefinite for the exact astronomical references which he wished to make in the records of his observations. The celestial bodies, the Sun, Moon, planets and stars and signs as groups of stars were the objects of study of the astrologist. In the life of Tycho Brahe by Dreyer, will be found the abstract of an oration on astrology by Tycho in his early life.

39. In what direction does the Sun rotate on its axis? C. O. T.

Answer: If our querist will think of this page as the plane containing the paths of the planets and the Sun in the center, and will then lay his watch down on the page, face up, the revolution of the planets around the Sun will be in a direction contrary to that of the hands of the watch. The rotation of the Sun on his axis (which is nearly perpendicular to the plane before mentioned) is in the same direction as that of the revolution of the planets. The Sun's rotation is determined by the motion of spots seen on his surface, also by the aid of the spectroscope.

40. Will a six-inch telescope show the shadows of the satellites of Saturn's moons on the disc of the planet?

Answer: I think not. They are too faint. I know of no such record.

41. Please give me a list of your lantern slides and quote price. J. S. T.

Answer: We have not a printed list of lantern slides made at Goodsell Observatory. This work has been done entirely from negatives of various celestial objects taken during the course of regular work. The few illustrations that have been sent out have been made at the request of friends interested in our work and who know something of the objects photographed and the value of the negatives. We could furnish from 40 to 50 good slides with or without color from our own negatives if desired. Those without color in lots of a dozen or more at 75 cents each. Those in color will cost more according to the work required. The principal subjects are the Sun, Moon, Clusters, Nebulæ, portions of the Milky Way, Star trails, Asteroid trails etc.

42. Will you explain to us why it is that while the day begins to increase at sunset about December 16 and continues to do so, it keeps on shortening in the mornings, the Sun rising later and later till about the middle of January when the Sun begins to rise earlier. Very few persons even observe this—but it continues until the day is longer in the evening by about a half hour ere it be-

gins to lengthen on the morning end. And the same is observable at the summer solstice. Explanations are made that remind one of "Explaining Metaphysics to the Nation!" "Who can explain his explanation?" HOLT.

Answer: It would seem, at first thought, as if the days ought to lengthen alike at both ends, as the Sun increases in declination. This would be true if we reckoned time by means of the sundial, or if the Sun crossed the meridian at 12 o'clock every day. But anyone by referring to an almanac will find the Sun recorded as "fast" or "slow" at different times in the year. The solar day (by day we now mean the interval from noon to noon) varies throughout the year. For the purposes of time-keeping a measure of uniform length is necessary and for that the ***mean solar day*** has been adopted, having the length of the average of all the true solar days. We may regard this day as measured by the revolution of a fictitious Sun moving at a uniform rate about the Earth and in the plane of the equator. It will be easily seen that when the real Sun is to the east of this fictitious Sun the hours of daylight in the forenoon will be shortened and the afternoon lengthened and when the real Sun is west of the fictitious one the reverse will be true.

In December the real Sun is moving toward the east with reference to the fictitious Sun so that the afternoons begin to lengthen before December 21, the date when the Sun begins to move northward, while for the same reason the forenoons continue to shorten after that date until the increase due to the more northern declination balances the relative easterly movement. In a similar manner in June the real Sun is moving to the eastward of the fictitious Sun, so that the forenoons begin to decrease before June 21 and the afternoons continue to increase for a few days after that time.

43. In considering the subject of Stellar Evolution, I have met with a difficulty which perhaps you may be able to clear up. Professor E. C. Pickering in his article on "The Constitution of the Stars," (*Astronomy and Astro-Physics*, Vol. XII p. 718.) says that in stars like α Aquilæ the H lines are broad and diffuse. He remarks that this could be accounted for by supposing these stars to have a rapid axial rotation, but that this would imply an equatorial velocity of over 100 miles a second, and is therefore improbable.

This sets me thinking; is it so very improbable? We know that many of the stars differ very much from our own Sun in mass, constitution, etc. Is there not a reasonable presumption that they may also enormously exceed it in velocity of rotation?

It seems to me, that on *any* hypothesis of stellar evolution, whether the nebular, the hypothesis of meteoric aggregation, etc., just before consolidation into a single mass, the detached masses which are about to constitute the visible photosphere, *must* be rotating with planetary velocity around the common centre of gravity, and therefore at first formation the photosphere would be rotating with this enormous velocity. I do not see any escape from this conclusion. This would mean, for a star equal in size and mass to our own sun, a rotation in about 3^h, or an equatorial velocity of over 200 miles a second. So that the supposed velocity of 100 miles a second does not seem *a priori* so very unlikely to occur *somewhere* in the universe. At the same time, there is reason to believe it would be somewhat exceptional. Thus the photosphere of Sirius cannot be rotating with anything like this velocity, the mass being only about twice that of our sun, and the distance from the centre enormously greater.

Now comes in my difficulty; if stars at their first formation were rotating with this enormous velocity, why should they not continue to do so? Obviously, in stars like Algol, which had a close companion of considerable magnitude, the

enormous tides raised in the primary, would soon reduce the velocity of rotation. (But even here there is a limit; thus I can understand the rotation-period of Algol being equal to the period of the companion or 2d 20^h 49^m, or being still less than this, but I cannot understand its being much greater.) Now, in the case of all the bodies in the solar system, *except the Sun*, there is no difficulty in accounting for the rotation-periods. The outer planets by reason of their great mass had much shorter original periods than the inner. In the case of these latter, the reduction was principally effected by the solar tides; in the case of the former the tides raised by the satellites. The longer period of Jupiter with regard to Saturn may be ascribed to the fact that the solar tides had still some effect on Jupiter, but hardly any on Saturn. But in the case of the Sun itself, the reduction seems inexplicable. And it is not that I have brought forward a theory, to which the Sun is an irreconcilable exception. The only hypothesis I urge, is that it does not seem to me by any means impossible that the widening of the H lines in the spectrum of α Aquilæ may be due to a very rapid rotation. That all stars originally rotated rapidly, and would still be rotating rapidly unless the velocity was in some way reduced, seems to me a necessary consequence of any hypothesis as to stellar evolution. I suppose it is wrong; in fact if the Sun is really irreconcilable, it *must* be wrong; but I cannot see how.

Another way in which the rotational velocity may have been reduced is internal friction; the layers internal to the photosphere having a longer period, because although nearer to the centre, the included mass is less. For stars like our sun this method has the advantage of not depending on any external body. But I feel doubtful as to whether this cause could have been so effective, because if, as seems probable, the mass increased in density towards the centre, the retardation due to this cause would evidently have been less.

In any case, if we admit that in stars when first formed the photosphere is rotating with planetary velocity; it follows that in large diffuse stars, as Sirians, where, owing to the rarity, friction can have but little effect, this velocity is very great; not indeed 100 miles a second, but much greater than the velocities we are accustomed to in our own Sun. J. R. HOLT.

Answer: There does not seem to be anything improbable in the supposition that *some* of the stars are rotating with great axial velocities; but we could hardly expect that this would always be the case. The velocity of rotation of a star would depend upon many circumstances.

(1) Supposing a nebulous mass to be endowed originally with a given angular velocity of rotation, it is evident that this angular velocity will steadily increase as the mass contracts, since the axial moment of momentum of the mass is constant, and the radius of gyration diminishes as the mass condenses. Hence the angular velocity of rotation will depend upon the stage of development. It is well known that such an increase in angular velocity as we have indicated would also give rise to an increase in the *linear velocity* of the periphery of the nebulous mass.

(2) The angular velocity with which the mass started would depend altogether upon the manner in which the matter composing it came together. If all the nebulous matter fell straight towards the centre, there would be no rotation about that point; the figures of some of the planetary nebulæ would seem to indicate that they have no rotatory motion. On the other hand, if any of the nebulous matter did not fall straight towards the centre, but rather to one side of it, the result would be a rotation in some direction. For the new mass would thus in its formation acquire a given moment of momentum about its center of inertia,

and this moment of momentum would always be preserved however much the nebula contracted. Thus there might arise all possible initial velocities of rotation. Besides, as we have seen in (1), the velocities would increase as the masses condensed.

Hence we conclude that all possible velocities probably exist among the stars, and we can see no inherent improbability in supposing the stars to be rotating in many cases at a velocity of 100 miles per second. But at present all positive knowledge on this point is wanting. (6).

GENERAL NOTES.

We are disappointed that some of our engraving of recent photographic work could not be completed in time for this number. It will be in readiness for our next issue.

The Peters-Borst Star Catalogue.—About 1889, the manuscript of a catalogue of 35,000 stars was completed at Litchfield Observatory of Hamilton College and made ready for publication. The observations and reductions were made in the main by Charles A. Borst, then assistant to Dr. C. H. F. Peters, director of Litchfield Observatory, who, it was claimed, planned the work and directed it in the beginning. When the manuscript was completed Mr. Borst refused to give it up, claiming it as his own. The matter was taken to court and tried before Judge Williams in Utica in the spring of 1889, and it was decided that the catalogue belonged to Dr. Peters. This trial attracted wide attention in consequence of the scientific features in the case and the prominence of the witnesses called to testify. Since the death of Dr. Peters which occurred in 1890, the contest has been maintained by Hon. Elihu Root of New York as administrator in the appeal made by Mr. Borst to the Court of Appeals of New York. From the Utica *Herald*, April 14, we learn that the Court of Appeals hand down a decision reversing that rendered in 1889 by Judge Williams and ordering a new trial.

While neither of the parties claimed that the star catalogue had commercial value, it was shown by the testimony of Professors Hall of Washington, and Boss of Albany, that the cost of work was not less than $12,000. For a statement of the case in important particulars, see Vol. VIII *Sidereal Messenger*, pp. 138, 455.

Brilliant as the Sun is, and all-important as he may appear to the ordinary observer, he is to astronomers only one of the hosts of heaven, in fact the nearest of the fixed stars . . . seen from the nearest of the stars, α Centauri, the Sun, together with the whole solar system, would appear as a star of about the 2nd magnitude near the Chair of Cassiopeia about 5° north of η Persei.—GORE: "Scenery of the Heavens."

The Sun rotates in twenty-five or twenty-six of our days,—I say twenty-five or twenty-six because (what is very extraordinary) it does not turn all-of-a-piece like the Earth, but some parts revolve faster than others,— not only faster in feet and inches, but in the number of turns,—just as though the rim of a carriage wheel were to make more revolutions in a mile than the spokes, and the spokes more than the hub. Of course no solid wheel could so turn without wrenching itself in pieces, but that the great solar wheel does, is incontestable; and this alone is a convincing proof that the Sun's surface is not solid, but liquid or gaseous.—LANGLEY in "New Astronomy."

Authority for Variable Star Maxima.—In our tables of prediction for variable star maxima under the title of Current Celestial Phenomena we have used the tables of Ernst Hartwig in the main, as they appear in the "*Vierteljahrsschrift der Astronomischen Gesellschaft.* These have been compared with other good tables and have been found to agree well generally, though not in all cases. Hartwig is regarded as good authority and this mention is made because of a statement involving some uncertainty by one of our correspondents found on pages 399 and 401 of this number.

The Poole Star-Charts.—We have received a copy of the Poole star-chart of the same size as the Poole Planisphere, on a circle 17 inches in diameter, the north pole of the heavens at the center, and extending to 50° south of the celestial equator. The constellations are all nicely shown with easy and definite boundaries, just as given on smaller scale in the star-chart of this number. The stars to the fifth magnitude and under are also given.

These large star-sheets can now be secured by astronomers, observers and students who may want to keep a record of celestial phenomena of special interest such as the paths of comets, planets, shooting stars, etc., etc.

This is an excellent idea, because all such records that are made neatly and accurately will be of great value. On the blank map everything is done except that which the observer wants to record, and the value of his record is in the fact that he has everything to a scale and all records are uniform. Every observer interested in good records of this kind to accompany the note-book will want to examine these star-sheets.

The Dawn of Astronomy —In *Astronomy and Astro-Physics* for March a full notice was given of the new book bearing the above title. It is written by J. Norman Lockyer and published by Messrs. Macmillan & Company of London and New York. It is attractive in appearance with large page, clear type, wide margin, very heavy paper, 121 illustrations and a contents of 425 pages. Price $5.

The design of the author is to determine the bearing of recent discoveries, as far as possible, on the early history of astronomy. The earliest civilizations from which information is now sought are those of the Nile Valley and adjacent countries in western Asia. India and China with paper records but no monuments of high antiquity are undoubtedly of more modern origin. If we can go back in China's and India's history 4000 years, and by Babylonian tablets 5000 years, those of Egypt may carry the inquirer back as far as 6000 or 7000 years. The key to this important investigation is in the worship of these ancient peoples, and as it consisted largely in deifying the heavenly bodies and in dedicating to them great temples and shrines without number, it is important to know which of the celestial bodies were chosen as objects of worship for these temples respectively, whose foundations have been uncovered extensively by the archeologists in modern times. During the last three years one important point of study has been to learn as accurately as possible, the directions in which the foundations of the various shrines lie in regard to the points of the compass. For, it is believed, that the worshippers who built them carefully placed them to face the rising point of the Sun, planet or star to which they were respectively dedicated. Now, it will readily be seen that the ancient tablets connected with these facts of orientation and the astronomer's knowledge of the places of the celestial bodies in very ancient times may give new and important information about the dawn of

astronomy. This new book fairly opens the field and directs attention to lines of study that may be pursued very profitably without doubt to gain valuable information.

Mt. Lowe Observatory.—I desire to inform the readers of your widely read journals that my future address will be Lowe Observatory, Echo Mountain, Los Angeles Co., California.

My instruments, which for the past twelve years have done service at the late Warner Observatory, Rochester, N. Y., are now *en route* to Pasadena, from which city they will be transferred to the Mt. Lowe Railway which will elevate them to the site of the Observatory, 3500 feet above the Pacific Ocean. This road, a trolly to Rubio Canyon the first station, and an electric cable road to Echo Mountain, has been in successful operation for nine months.

Work on the new mountain Observatory will be begun immediately upon my arrival. Already there are established there the telegraph, telephone and express offices, a post office and mammoth hotel, and an illustrated daily newspaper, the Mt. Lowe Echo, is published.

With nine degrees of southern declination not visible from this latitude nor from most of the observatories of the world, and having an assurance of nearly three hundred clear nights per year, I am hoping for a continuance of my nebulæ work begun in this city, and successfully prosecuted until stopped by the electric street lights. LEWIS SWIFT.

Rochester, N. Y., April 12, 1894.

Casual observers are referring the fine aurora of Friday, March 30th, to the spots on the Sun which happened to be most conspicuous at the time, which in this case were east of the meridian and far north. There was, however, a disturbance marked by two spots smaller it is true, but in the precise location which has been found to be characteristic when there is an aurora at this season of the year, namely at the eastern limb and south of the equator. In other words it is the position and not the size of the spots that determines the auroral effect and its recurrence at the precise interval of the rotation period of the Sun.

M. A. VEEDER.

Aurora —During the display of aurora borealis on the evening of March 30th, a prominent feature was the converging of the streamers and waves of light to a point on the meridian about 15 degrees south of the zenith. When first seen here, a few minutes before 8 o'clock, the light was pretty evenly distributed over the sky from east to west and extending from the north towards the south as far as a line parallel with the horizon running through Sirius. This, at first was quiescent and very similar in appearance to a stratum of luminous cirrus clouds. This soon broke up, however, into streamers and filaments of light, some of which were bright pink in color, all pulsating rapidly towards a point which at 8:30 P. M. was apparently on the meridian, nearly on a line with northerly star in the sickle of the Lion. The most remarkable part of the display was the unmistakable flashing of streamers from the *south*, as well as other quarters, to the point referred to. In fact I do not remember to have ever seen an aurora whose southerly limit was so near the horizon, and which showed from *all* directions a movement towards a definite point. It would be interesting to know if this was observed elsewhere and what explanation can be given of the phenomenon referred to. J. H. EADIE.

Bayonne, N. J.

The Sun-heat falling on one square mile corresponds to over 750 tons of water raised *every minute* from the freezing point to boiling. The Sun's heat falling on the Earth in each *minute* would raise to boiling 37,000,000,000 tons of water.—LANGLEY in "New Astronomy."

Mira Ceti.—Observations of this variable star have shown that it has continued to brighten since the predicted date of maximum (February 17). At the present time (March 4) it is a trifle brighter than δ Ceti, a star of magnitude 4.2, and is quite a conspicuous naked-eye star for a little while after darkness sets in. There are no indications that it has even yet reached the maximum. On some previous occasions it has reached the second magnitude. The predicted date of maximum was no doubt calculated on the basis of the period of 333 days deduced by Argelander, but it is well known that the period, like the maximum brightness, is not always the same. There is evidence of a regular irregularity to the extent of twenty-five days. The present apparition is anything but favorable, owing to the proximity of the star to the sun.—*Nature*, March 15, '95.

BOOK NOTICES.

The Amateur Telescopist's Hand-book by Frank M. Gibson, Ph D.; L. L. B. New York; Messrs. Longmans, Green & Co., publishers, 15 East Sixteenth St. 1894. pp. 163.

This is a plain, unpretentious little book intended for those who have telescopes under 4 inches of aperture, and who wish to learn the proper care and use of such an instrument. The first eighty pages is given up to the consideration of the telescope under nine chapters. The first chapter deals with the telescope in regard to its principles and powers. The small telescope has a useful place in the study of astronomy if the young observer knows how to apply it. He shows the principles of the instrument. They are plainly presented and illustrated. The eye-pieces are given also, and the number and power of each adapted to apertures varying from 2 inches to 6 inches. Brief statements are given showing what is meant by the magnifying, defining and illuminating powers of the telescope. The second chapter treats of testing the object glass, eye-pieces and tubes. It is excellent as far as it goes. The illustrations of deformed images with explanations of causes are definite and helpful. Chapter third particularly describes the equatorial stand, and fourth has to do with the accessories. The fifth chapter, on the care of the telescope, we have given elsewhere in this number, in full, and and it will serve to illustrate the way the author deals, not only with the subject in hand, but also indicate somewhat of the character of the book as a whole. The sixth treats of the use of the telescope in seven pages; the seventh, is concerned with the observations of the stars, nebulæ, Sun and Moon to which twelve pages is devoted. Then follows chapter ninth which gives the prices of small instruments of various sizes by different makers, mounted, unmounted and portable.

The remainder of the book consisting of 80 pages is given up to a list of celestial objects arranged under the constellations to which they belong, the constellations themselves being arranged in alphabetical order. This list contains 468 celestial objects consisting of double stars, clusters, variables, peculiar stars and nebulæ. This book will be of real service to the amateur who has had little experience with the telescope.

Total Eclipses of the Sun. By Mabel Loomis Todd. Illustrated. Boston: Roberts Brothers, publishers. No. 1 Columbian Knowledge Series. 16mo, cloth, pp. 244. Price $1.

Mrs. Todd's neat little book is the first of the *Columbian Knowledge Series*, under the editorship of Professor D. P. Todd of Amherst College, and is certainly attractive at first sight, whether it be in the thoughtful taste of cover decoration handsomely designed by the gifted Mrs. Huggins of London, or the varied and ample illustration of the text, which numbers 223 cuts and full-page plates.

The author begins with a chapter on eclipses and eclipse tracks in general, showing how the path of total shadow would look to one so placed to view it as a whole, if it were a fixed trail on the Earth's surface. The figures of the shadows, the comparative sizes of the Sun, Moon and Earth, and the easy, clear way of associating a multitude of interesting facts pertaining to these bodies, their orbits and their specific relations in important eclipses, will enlist the interest of the reader at once in the plan and purpose of the book. The especial value of the text for the careful student or instructor in the elements of astronomy is the abundant references to authority and useful books on almost every page. This has cost labor and much of it, on the part of the author, for very much of this useful information will not be found in text-books or other works easily accessible to the popular reader. For example, the description of the total eclipse in the second chapter very aptly and fully illustrates, by cut and word, the singular crescents visible under foliage during the partial eclipse, and the fleet shadow bands as they curiously painted the side of an Italian dwelling seen in the total eclipse of 1870.

The following are titles of other chapters:—Minor phenomena, interimercurian planets, the solar prominences, the corona, eclipses in the remote past, mediæval and later eclipses (A. D. 5 to 1842), modern eclipses (1842—1880), recent eclipses (1882—1893), eclipses and the telegraph, Automatic eclipse photography, the predicting of eclipses, selecting stations, future eclipses, lists of eclipses with charts, biographical sketches and an index.

This number makes an auspicious beginning for the Columbian Knowledge Series, and ought to find ready sale as its *merits* are known.

Bibliography of Astronomy for February, 1894.

GLYDÉN (H.) Traité analytique des orbites absolues des huit planètes principales. 1. Théorie générale des orbites absolues. 4to. Stockholm, 1894. $7.50.

JOHNSON (S. P.) Notes on astronomy: a complete elementary handbook, with a collection of examination questions, edited by J. Lowe. 8vo. 1894. 90 cents.

LYNN (W. T.) Remarkable comets. Second edition. 12mo. 1894. 15 cents.

LYNN (W. T.) Celestial motions: a handy book on astronomy. 8th edition. 3 plates. 12mo. 1894. 50 cents.

MARTIN (P.) Untersuchungen über die wahrscheinlichste Bahn des Cometen 1825 I und über seine Identität mit dem Cometen 1790 III. 4to. Goettingen. 1894. f 1.

PRATT (H.) Principia nova astronomica. 4to. 1894. $2.65.

PROCTOR (R. A.) The orbs around us. New edition. 8vo, cloth. 1894. 90 cts.

The above works can be purchased from Wm. Wesley & Son, 28 Essex Street, Strand, London, England.

Errata.—Page 301, line 8, for "Techner's" read "Fechner's." Page 304 line 5 from end for "increases" read "is multiplied."

PUBLISHERS' NOTICES.

The Poole Series of Star Charts are coming into very general use. They are highly commended by those who have used them most.

On the accompanying chart we give the path of the new Denning Comet, as observed and computed at Goodsell Observatory of Carleton College. It is too faint for small telescopes. For the paths of the Asteroids Ceres, Vesta and Pallas, see the chart in April Number.

By a correspondent in Marsivan, Turkey, who has seen them, we are told that the Poole Star Charts are upon the walls of the recitation room in Girls' School in Anatolia College. They are used by the teacher of the elements of Astronomy. The teacher of science in the American School for Girls, in Constantinople, Turkey, is also a regular subscriber to POPULAR ASTRONOMY.

The following is a summary of the contents of POPULAR ASTRONOMY during the first half year of its publication:

Plates: The Moon (two views), Jupiter's Comet Family, Photograph of Stars about the North Pole, Jupiter's Comet Family (a second presentation), Distances of Stars whose Parallaxes have been Determined during the Present Century, Lick Observatory Eclipse Station (two views), The Nebula in Andromeda, The Yerkes Telescope, Portrait of Daniel Kirkwood, Portrait of E. E. Barnard, Circumpolar Stars of Long Period, Photograph of the region about Neptune in Taurus, Nov. 7th, 1893.

In addition to these plates a great variety of illustration is found in the body of the print.

Subjects of Serials: Constellation Study, The Spectroscope, Nebulæ and Comet Seeking, Shooting Stars, Variable Stars, Glass for Optical Instruments, Astronomy with a Small Camera.

Shorter Articles: The Moon, the Asteroids, Observation of the Aurora, Jupiter's Comet Family, Harvest Moon, Time and Time Signals, 40-foot Telescope of the Lick Observatory Eclipse Expedition, Jupiter's Fifth Satellite, Distances of Stars whose Parallaxes have been Determined during the Present Century, Jupiter at Opposition, The Yerkes Telescope, Orbits of Comet 1889 V, Life of Daniel Kirkwood, Visualizing the Earth's Annual Motion, Early Life of E. E. Barnard, The Fixed Stars, Sirius and Its Companion, First Observations of the Sun and Moon, Faith in the Integrity of the Interstellar Medium.

The latter part of each number is devoted to matter presented under the following heads: The Face of the Sky, Planet Notes and Tables, General Notes, Practical Suggestions.

One number more will complete the first volume of POPULAR ASTRONOMY. All readers interested in this publication are requested to call attention to this new magazine. It is easy *now* to supply *all* the numbers of this first volume. It may not be so a few months hence.

An interesting feature of the little periodical, POPULAR ASTRONOMY, (Northfield, Minnesota), is the map of the constellations visible at 9 P. M. on the 15th day of the current month, published in each issue. Few men and women recognize that there is within their reach a most exalted pleasure, that of studying the starry sky. Parents who desire to arouse and elevate their children's minds, could hardly find a better way than that of leading them forth on starry evenings, and aided by such maps as these, teaching them how to "consider the heavens."—*N. Y. Evangelist, April 12, 1894.*

MAP OF THE
CONSTELLATIONS
VISIBLE MAY 15,
AT 9 P. M.

REDUCED FROM SECTION OF
POOLE BROTHERS' PLANISPHERE.

BY PERMISSION.

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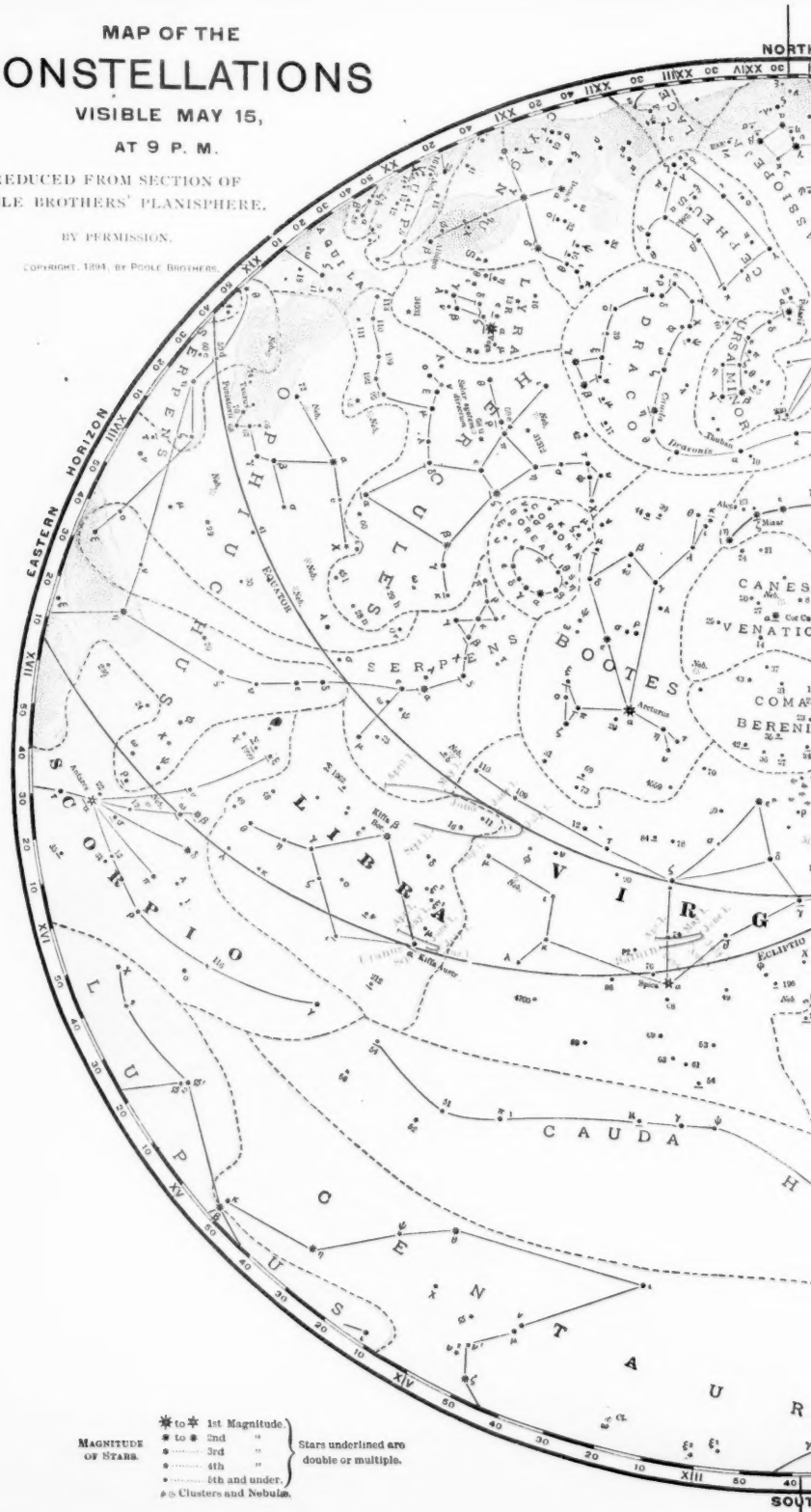
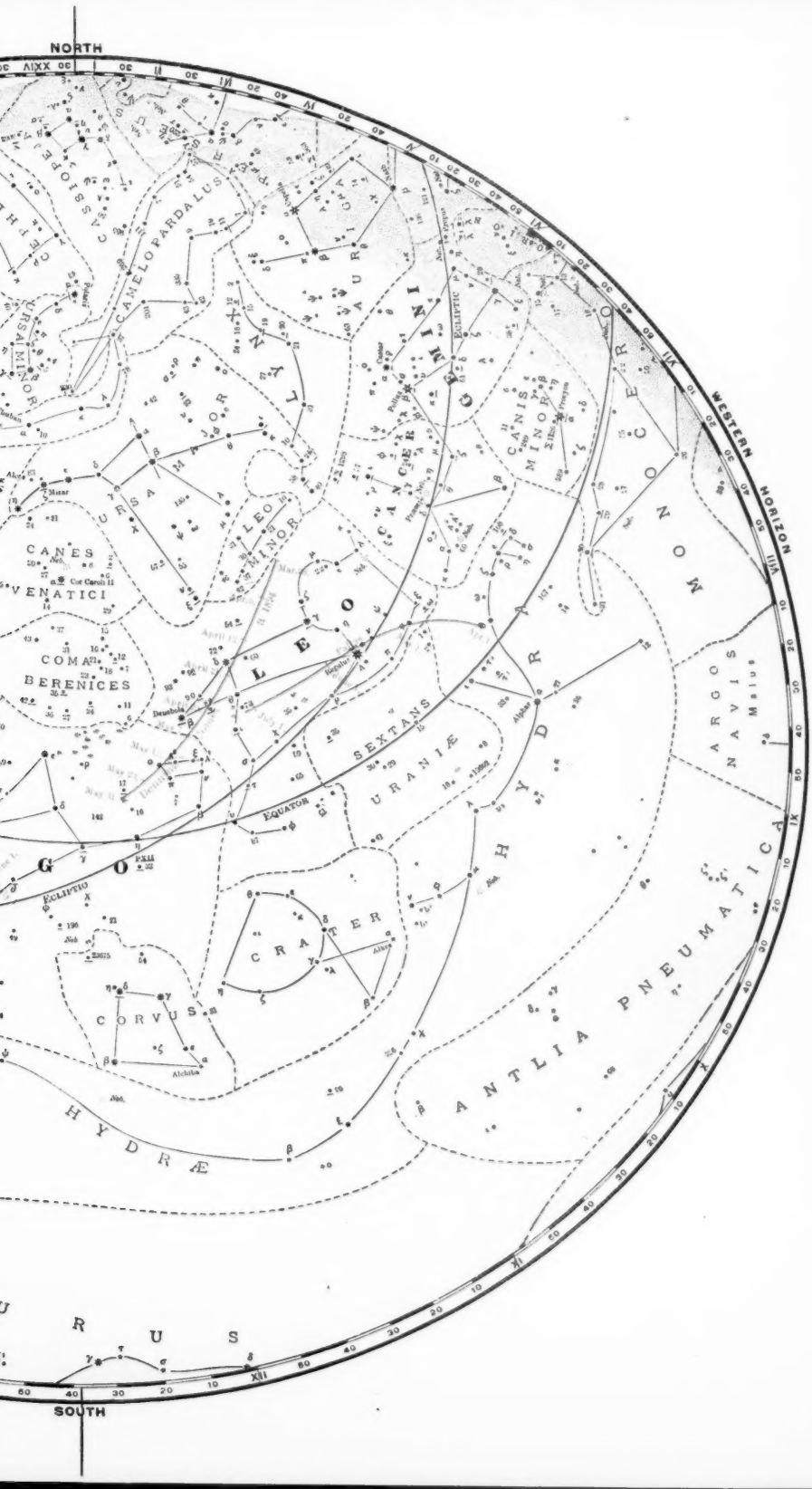


MAGNITUDE OF STARS.		
✱ to ✱	1st Magnitude.	Stars underlined are double or multiple.
✱ to ✱	2nd "	
✱	3rd "	
✱	4th "	
✱	5th and under.	
✱	Clusters and Nebulæ.	


NORTH
WESTERN HORIZON
SOUTH
CAMELOPARDALUS
AURIGA
GEMINI
CANCER
CANIS MINOR
PROCYON
LYNX
URSA MAJOR
LEO MINOR
CANES VENATICI
COMA BERENICES
LEO
SEXTANS URANIÆ
EQUATOR
ECLIPTIC
CRATER
CORVUS
HYDRÆ
HYDRA
ARGO NAVIS
ANTLIA PNEUMATICA
Procyon
Regulus
Denebola
Algieba
Alphard
Alkes
Alchiba
Cor Caroli II
Mintaka
Phecda
Mizar
Alioth
Castor
Pollux
Alhena
Wasat
Mirzam
Muliphein
Gomeisa
Aspidiske
Nunki
Ascella
Kaus Australis
Sabik
Rasalhague
Alphecca
Arcturus
Spica
Vindemiatrix
Algorab
Zosma
Chort
Denebola
Alkaid
Dubhe
Merak
Phecda
Megrez
Alioth
Mizar
Alcor
Polaris
Kochab
Pherkad
Schedir
Caph
Ruchbah
Segin
Navi
Tsih
Caph
Algol
Mirfak
Alpheratz
Algenib
Markab
Scheat
Enif
Sadalmelik
Sadalsuud
Deneb Algedi
Dabih
Nashira
Algedi
Giedi
Deneb
Sadr
Gienah
Aljanah
Rukbah
Alderamin
Cepheus
Cassiopeia
Andromeda
Pegasus
Aquarius
Capricornus
Sagittarius
Scorpius
Ophiuchus
Hercules
Corona Borealis
Bootes
Virgo
Libra
Lupus
Centaurus
Crux
Triangulum Australe
Apus
Octans
Hydrus
Reticulum
Horologium
Eridanus
Fornax
Sculptor
Phoenix
Grus
Tucana
Indus
Pavo
Telescopium
Corona Australis
Ara
Norma
Circinus
Musca
Chamaeleon
Volans
Carina
Vela
Puppis
Pyxis
Antlia
Sextans
Crater
Corvus
Leo
Cancer
Gemini
Taurus
Aries
Pisces
Aquarius
Capricornus
Sagittarius
Scorpius
Ophiuchus
Hercules
Lyra
Cygnus
Aquila
Delphinus
Sagitta
Vulpecula
Equuleus
Pegasus
Andromeda
Cassiopeia
Cepheus
Lacerta
Perseus
Auriga
Camelopardalus
Lynx
Ursa Major
Ursa Minor
Draco
Canes Venatici
Coma Berenices
Leo Minor
Canis Minor
Monoceros
Orion
Lepus
Columba
Caelum
Pictor
Dorado
Mensa
Volans
Carina
Vela
Puppis
Pyxis
Antlia
Hydra
Crater
Corvus
Sextans